PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

VOL. X JANUARY 1956 NO. 1

Previous issue published October 26, 1955

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PACIFIC SCIENCE is published quarterly by the University of Hawaii Press, in January, April, July, and October. Subscription price is $3.00 a year; single copies are $1.00. Check or money order payable to University of Hawaii should be sent to University of Hawaii Press, Honolulu 14, Hawaii, U.S.A.

The Use of Pandanus Fruit As Food in Micronesia[1]

CAREY D. MILLER, MARY MURAI, and FLORENCE PEN[2]

THE PANDANUS, sometimes called screw pine, is widely distributed in Southeast Asia and all the tropical Pacific islands, but according to Dr. Harold St. John, Professor of Botany at the University of Hawaii, it is only in Kapingamarangi and the Marshall, Gilbert, and Ellice Islands that one finds the varieties with choice edible fruit. On the small and relatively dry low islands or atolls, pandanus and coconuts are the principal and sometimes the only vegetable foods.

Almost all parts of the pandanus plant are used by the inhabitants of these islands, the leaves provide material for clothing and shelter, and for household use such as baskets and mats. The chief edible part is the fruit, especially the fleshy base of the keys.

There are two distinct sexes of trees for all varieties, male (staminate) and female (pistillate). The pistillate trees bear fruits of different sizes, varying from the inedible ones 3 or 4 inches in diameter, which weigh a pound or less, to the very large edible fruits weighing 20 to 30 pounds (see Fig. 1). A 30-pound fruit has approximately 50 keys and a core and stem weighing about 2 pounds.

Each fruit is made up of many small sections called keys (botanically a phalange), because though irregular in shape, they fit closely together to form a solid fruit. In a large fruit the keys are 3 to 4 inches long; at the outer end they are 1½ to 2 inches in diameter and at the inner end near the core ¾ to 1 inch (see Fig. 2). The rough outer surface may be green or yellow when ripe, but the inner edible end is always yellow-orange in color. The inedible varieties have fruits which, though smaller, look just like the edible types, but they are extremely astringent and bitter.

The chemical analyses and studies of the nutritive values of pandanus fruit reported in this paper were made on fruits from Micronesia: Majuro and Mille Atolls of the Marshall Islands and Kapingamarangi of the Caroline Islands.

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[1] Published with the approval of the Director as Technical Paper No. 333, University of Hawaii Agricultural Experiment Station.

This work has been a joint project of, and financially supported by, three agencies:

The Pacific Science Board of the National Research Council provided a fellowship under which Mary Murai did the field work and made some of the analyses.

The United States Department of Agriculture, through a contract sponsored by the Human Nutrition Research Branch, Agricultural Research Service, provided the funds for most of the food analyses, which were made by Florence Pen.

The Foods and Nutrition Department of the University of Hawaii Agricultural Experiment Station furnished the laboratory, the equipment, and the necessary overhead, as well as the financial cost of the supervision for the analyses of the foods and the preparation of the manuscript by Carey D. Miller.

Pandanus was only one of the foods studied under this project. The complete publication will appear elsewhere.

[2] Department of Foods and Nutrition, University of Hawaii Agricultural Experiment Station. Manuscript received August 26, 1954.

USE AS FOOD

The earliest account of the edible pandanus fruit and its use by the natives of the Marshall Islands is by Kotzebue (1821, 2: 8) who early in 1816, when he first touched at the Radak Island chain, observed "they had nothing with them except a few grains of pandanus, which they constantly chewed."

Kotzebue and Chamisso, the naturalist who accompanied the expedition, tell of being served "pandanus juice" which was pressed from the keys after they were bruised with a stone and which Kotzebue states, "had a sweet and spicy taste" (1821, 2: 10).

Discussing the abundant pandanus, Chamisso stated: "It is also diligently cultivated; numerous varieties, with improved fruits, which are to be ascribed to cultivation, are propagated by layers" (Kotzebue, 1821, 3: 150).

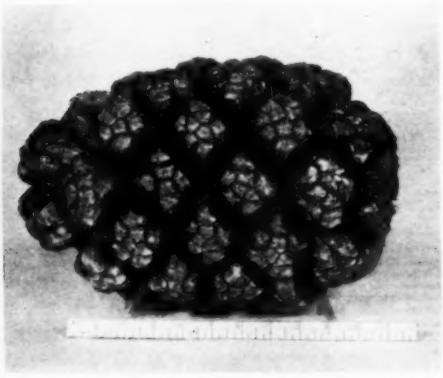

FIG. 1. Pandanus Fruit—Joibeb. From Ebon, Marshall Islands; weight 19¾ pounds.

Kotzebue (1821, 2: 75) opined that "the pandanus contains very little nourishment," but noted that the natives "enjoy extraordinary health, and attain to an advanced and cheerful old age." His picture of the teeth, however, is quite in contrast to that of some of the early voyagers who remarked on the fine teeth of the Polynesians (Cook, 1784, 1: 380; King, 1784, 3: 125; Ellis, 1832–36, 1: 81). Kotzebue states: "All the islanders are great lovers of sweet things; and their chief food, which they draw from the sweet pandanus fruit, is probably the reason, that even children of 10 years old have not good teeth, and that they have generally lost them all in the prime of life" (1821, 2: 17).

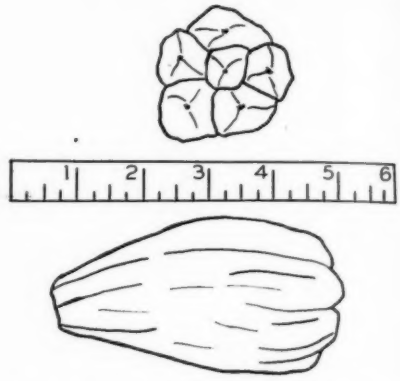

FIG. 2. A single key from a large Lojekerer, side and end views. Sketch by M. Higa.

Chamisso (Kotzebue, 1821, 3: 150) gives a rather detailed account of the making of pandanus paste (mōkan), which is essentially the same method used today. He also observed that the paste was "carefully preserved as a valuable stock for long voyages."

Pandanus has apparently always been an important food in the Marshall as well as the Gilbert Islands as it figures prominently in their folklore and is commonly considered to have come with their creation (Grimble, 1933–34, 54: 85, 97; James Milne, personal communication).

Selection and propagation must have been practiced by these isolated people for many years in order to have developed the fine edible varieties which are limited in their distribution.

No edible pandanus was in evidence when the dietary study was made in the Caroline Islands (Murai, 1954), but it was thought that it might have been out of season. Chamisso (Kotzebue, 1821, 3: 184) states that at the time of their visit (1817) that although

the pandanus grows on all the islands, "the fruit is neither eaten, nor ever used for an ornament. None of the improved kinds are found there."

In the Marshall Islands, each household owns some pandanus trees which may be near the house or at some distance from the dwelling. When ripe and ready for use, the large fruits are cut from the tree with a bush knife and the keys broken apart to be eaten raw or cooked.

Pandanus was in season in the Marshall Islands from January to the end of May, 1951, and at the time the dietary study was made in April both pandanus and breadfruit were being used (Murai, 1954: 14). On the low islands, pandanus is one of the important foods between breadfruit seasons, and, when breadfruit is abundant, pandanus may or may not be used.

The most common method of eating pandanus is to gnaw at the soft inner ends, leaving the long tough fibers attached to the keys. Children and adults seem to chew the keys almost continuously during their waking hours. People eat them much as Westerners might eat nuts or candy or smoke cigarettes. Chewing pandanus keys, talking and gossiping are an important part of their social life. Records of the amounts eaten and the nutrients furnished are given in the section on Composition and Nutritive Value.

The hard portion of the keys is used as fuel. The inedible ends also contain the seeds which can be removed only with great difficulty because they are enclosed in an unusually tough woody case and people rarely bother to extract them, although they are sometimes eaten.

In the raw state, the edible portion of the pandanus is merely a juice pressed from the cells embedded in coarse fibers. It is not a pulp but a liquid which when extracted in the laboratory has a small portion of solid material that settles to the bottom of a beaker. The juice is sweet and subacid with a pungent aromatic flavor. When cooked the starch causes the juice to thicken and the edible portion becomes a soft pulp, resembling mashed sweet potatoes both in color and in texture. The flavor is similar to the raw juice.

If a good supply of other foods is available, the pandanus keys are more likely to be eaten in the raw state because people simply do not bother to cook them. But when the pandanus constitutes a large proportion of the diet (such as was observed in February, 1951, at Mejit Island, Mejit Atoll; Utirik Island, Utirik Atoll; and Ailuk Island, Ailuk Atoll; in the drier northern Marshall Islands), it is eaten cooked as well as raw, probably to add variety. It is also combined with other foods as listed below.

A glossary of the names of edible pandanus fruit, and products made from it, which were observed by one of us (M.M.) in the Marshall Islands in 1951 is as follows:

Bop—The pandanus tree or the whole fruit made up of many keys.

Kōbeo—Raw pandanus fruit.

Eroum—Boiled or baked pandanus.

Joanrong—Pandanus juice.

Mōkan—Cooked and preserved pandanus pulp (see below for preparation).

Beru—Soft pulp from boiled pandanus cooked with arrowroot flour to produce a sweet dessert.

Mokanrul—Pulp of cooked pandanus fruit mixed with grated coconut and baked.

Jakaka—Shredded fresh (uncooked) pandanus which is dried for almost one week and used as a confection.

The native people in most of the islands still make all the products from pandanus which their ancestors made. But where western influence is strong, or where more favorable conditions permit growing a greater variety of foods, they no longer preserve the pandanus, though they continue to enjoy it in the raw or freshly cooked state. Two products which we analyzed, that can be stored and used for emergency or as wanted, pandanus paste and pandanus flour, are described below.

Pandanus Paste (Mōkan)

Wherever the pandanus constituted an important native food in the fresh and cooked state pandanus paste was also made, and is still made in some areas.

Many reports of scientists in the 19th and 20th centuries tell of the preparation of pandanus paste which they also refer to as pandanus conserve or preserve (Kotzebue, 1821, 3: 150; Finsch, 1893: 142; Kramer, 1906: 427; Kurze, 1887; Wendler, 1911: 271).

Details of the process may vary slightly in different localities but in general the paste is made as follows: The separated pandanus keys are cooked in a deep earth oven with alternating layers of fruit and leaves for as long as 2 days, though one report states for 12 hours (Wendler, 1911: 271).

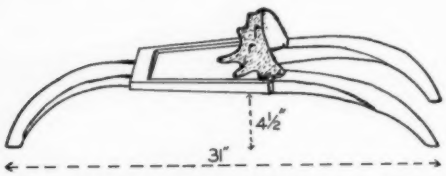

FIG. 3. Beka of traditional Marshallese type from Arno Atoll, Marshall Islands, collected in 1950 by Dr. Leonard Mason. Sketch by F. Pen.

The soft ends of the keys are rubbed against a scraper (formerly of shell, Fig. 3, but now more likely of metal) and the orange pulp is collected and dried on leaves. When it becomes a sticky mass, it is dried further over hot stones until it is thick and rather firm. The flat cakes are then rolled or pressed into a firm mass, wrapped in plaited pandanus leaves and firmly tied with coconut cord as shown in Figure 4.

These rolls are reported to have been of enormous size formerly—6 feet long and more than 1 foot in diameter (Finsch, 1893: 142; Kurze, 1887; Wendler, 1911: 271). Today they are more likely to be 12 to 15 inches long and 3 or 4 inches in diameter (Fig. 4). The model shown in Figure 5 is only 8 inches long.

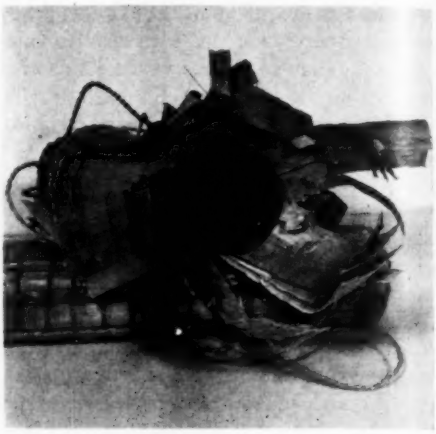

FIG. 4. Roll of pandanus paste in lauhala wrappings, collected at Mille Atoll by Dr. Kenneth P. Emory.

One account of the preparation of pandanus paste (Wendler, 1911: 272) calls attention to the unsanitary methods employed in making it, but probably they were no less sanitary than the handling of other foods.

The product is brown in color and tastes much like date or fig paste. It will keep a year or more and was formerly an important manner of preparing food for use on voyages and for storage in case of famine as well as for a regular food supply when the pandanus was not in season (see p. 4).

FIG. 5. Model roll of pandanus paste, collected at Majuro Atoll, by M. Murai.

Pandanus Flour

Although the accounts of anthropologists (Buck, 1950: 29; Grimble, 1933–34: 36) vary somewhat as to the method of making the dried product, referred to as "pandanus flour," they agree on the essential points which are here summarized.

The soft ends of the keys are cut off, placed in some type of coconut basket and cooked, usually by steaming in an earth oven until tender, about 1 hour. The cooked fruits are pounded to a paste which is made into large thick flat cakes, about 14 inches in diameter, which are dried (Buck, 1950: 29). In some places they are dried in the sun and finished over a grill of hot stones, and in other places they are dried over the hot stones first and then placed in the sun. The sun drying may take several days. They are usually given a final drying over hot stones and then the large crisp cakes are broken and pounded to a coarse flour-like consistency.

The product is dull yellow with a pleasant pungent odor. It can be stored in tubular containers made of plaited pandanus leaves and will keep for several years.

Grimble (1933–34: 39) reports that formerly pandanus flour and water were often the only food and drink taken on long voyages. The powder was simply mixed with water and drunk.

Dr. Katharine Luomala of the Department of Anthropology, University of Hawaii, who made observations in the Gilbert Islands in the latter half of 1948, especially on the Island of Tabiteuea, says that she saw both pandanus flour and pandanus paste being made (personal communication).

To our knowledge the pandanus is not made into a flour in the Marshall Islands as it is in the Gilberts and in Kapingamarangi.

SAMPLES ANALYZED

The number of edible varieties of Pandanus in the Marshalls is uncertain, but St. John states that he has collected several score (personal communication).

One of us (M.M.), collected what were believed to be two native varieties of edible pandanus for chemical analyses, but St. John, who has examined the keys, believes them to be the same botanical species.

LOJEKERER (local name), *Pandanus pulposus* Martelli: This variety is the most common and widely distributed in the Radak chain. Four fruits on Majuro Island in April and May, 1951, had the following weights: 23, 32, 25, and 30 pounds. The keys are large, 3 to 4 inches long, 1½ to 2 inches in diameter, and weigh from about 3 to 7 ounces (100 to 200 grams) (Fig. 2). They are eaten both raw and cooked.

According to our informants this variety usually fruits but once a year. Our samples were obtained toward the end of the fruiting season.

JOIBEB (local name), *Pandanus pulposus* Martelli: This variety, which according to our informants, is also widely distributed, was thought to have originated on Jaluit of the Ralik chain. Four fruits on Majuro Island in April and May, 1951, had the following weights: 24, 30, 20, and 25 pounds. These fruits also had large keys.

We were informed that on Jaluit and Ebon, this variety usually fruits twice a year.

Under Composition and Nutritive Value, for clarity, we refer to the fresh pandanus by the two local names as if they were two horticultural varieties.

Sample 1. Pandanus, Fresh

1. Marshallese name—Lojekerer. *Pandanus pulposus* Martelli.
2. Date and place of collection: May 20, 1951. Uliga Island, Majuro Atoll.
3. Date vitamin assays begun: October 11, 1951. (Other analyses were made at a later date with repetition of moisture content to determine if there had been any loss as a result of freezer-storage.)

4. Preparation of sample after collection: Keys from three fruits, each from a different tree, were weighed, wrapped in groups of three in several thicknesses of wax paper, labeled, and placed in the freezer.
5. Transportation and storage: Frozen at 0° F. and held in Navy cold storage for 8 days. Kept frozen at 12° F. on a Navy vessel for 9 days enroute to Honolulu. Transferred to Foods and Nutrition Department, University of Hawaii Agricultural Experiment Station. The samples were examined and rewrapped in the same wax papers with an outer wrapping of aluminum foil. The keys were kept in freezer-storage at 0° to −5° F. until analyses were made.
6. Preparation for analyses: Samples were thawed in the refrigerator and then brought to room temperature. Total weights of keys and weights of edible portions were recorded. Edible portions were cut into small pieces and blended in the Waring Blendor without addition of liquid. The coarser fibers were removed by putting slurry through two thicknesses of cheesecloth to obtain a value more representative of the portion actually eaten. The juice so extracted was put into brown glass bottles filled with carbon dioxide, closed tightly with bakelite tops, labeled and held at 0° F. until all analyses had been made. Refuse, 59 per cent.

Method of Crude Fiber Analyses: To remove a large portion of the sugars from the pandanus samples to be analyzed for crude fiber, the samples were weighed, transferred quantitatively to filter paper in funnels, and extracted with distilled water in the refrigerator for almost 2 weeks. (Refrigeration was necessary to prevent the growth of molds.) The water extracted residues were dried on the filter papers for 48 hours, below 70° C., and then extracted with ether in the usual manner. The ether extracted residues and the attached filter paper were used for the crude fiber determinations. A blank of filter paper was run simultaneously with each of the triplicate determinations of fiber.

Sample 2, Pandanus, Boiled

1, 2, and 3 same as sample 1.
4. Preparation of sample after collection: Keys from the same fruit as sample 1 were boiled without a cover in a large glass beaker of plain water for 30 minutes. The water was drained off and the keys cooled. Keys were weighed and labeled as stated for sample 1.
5. Transportation and storage: Same as sample 1.
6. Preparation for analyses: Same as sample 1, except that in addition to cutting off the soft ends, any soft juicy pulp remaining in the fibers was scraped out with a dull knife and added to the soft ends before mixing in the Waring Blendor. Refuse, 65 per cent.

Sample 3, Pandanus, Fresh

1. Marshallese name—Joibeb. *Pandanus pulposus* Martelli.
2. Date and place of collection: May 15, 1951. Majuro Island, Majuro Atoll.
3. Date vitamin assays begun: October 11, 1951. Other analyses same as sample 1.
4. Preparation of sample after collection: Keys from three fruits from three different trees, prepared in the same manner as sample 1.
5. Transportation and storage: Same as sample 1, but product held in Navy cold storage for 13 days before shipping.
6. Preparation for analyses: Same as sample 1. Refuse, 66 per cent.

Sample 4, Pandanus, Boiled

1, 2, and 3 same as sample 3.
4. Preparation of sample after collection: Keys from same three fruits as sample 3 were boiled in plain water in a large glass beaker for 30 minutes without a cover. After cooling, the soft end of the keys was

scraped with a dull knife to remove the pulp that constitutes the edible portion. The following were mixed in a Waring Blendor: 164 grams of pulp, 90 milliliters of 1 per cent oxalic acid, and shortly before slurry was completely blended, 5 milliliters of chloroform and 3 drops of mixed tocopherols were added. The samples were transferred to brown glass bottles, the plastic caps screwed down tightly and sealed with paraffin wax. Refuse, 75 per cent.

5. Transportation and storage: Bottles were kept at 36° F. at Uliga, Marshall Islands, until shipped by plane on May 29, 1951. The bottles were packed in cartons and shipped by air without refrigeration. The flight took 2 hours to Kwajalein, bottles were refrigerated at 36° F. in a Navy reefer during a stopover of 20 hours at Kwajalein. The flight from Kwajalein to Honolulu took 9 hours during which time they were not refrigerated. Samples were transferred to the Foods and Nutrition Laboratory and kept at 36° F. until analyzed.

Sample 5, Pandanus Paste

1. Marshallese name—Mōkan.
2. Date and place of collection: Summer of 1949. Mille Atoll, Marshall Islands, by Dr. Emory.
3. Date vitamin assays begun: October 10, 1949, except carotene which was determined in January, 1951.
4. Preparation: Similar to method described on page 6, but exact times of cooking and drying are not known. Thin slices were made into a roll approximately 3 inches in diameter and 14 inches long, covered with plaited pandanus, and tied securely wtih sennet (see Fig. 4).
5. Transportation and storage: Transported by ship without refrigeration to Honolulu. Brought to the Foods and Nutrition Department in September, 1949. Kept at room temperature until analyses were begun, samples were removed from wrappings and thereafter kept refrigerated in tightly closed bottles.

Sample 6, Pandanus Flour

1. Polynesian name: paku harahara.
2. Date and place of collection: July, 1947. Kapingamarangi Island, by Dr. Emory.
3. Date vitamin assays begun: Vitamin A feeding tests, July, 1948; other vitamins, August, 1948.
4. Preparation: Similar to method described on page 7.
5. Transportation: Transported by ship without refrigeration to Honolulu. Delivered to the Foods and Nutrition Department in September, 1947.
6. Storage: Stored in tightly closed bottles in the refrigerator until analyzed.

ANALYTICAL METHODS

The thiamine, riboflavin, and reduced ascorbic acid of pandanus fruits were assayed chemically and niacin was determined microbiologically by the methods outlined by the Association of Vitamin Chemists (1951). The carotene content was measured physically by the chromatographic method of the Association, except that the extraction procedure was facilitated by using a mixture of solvents (petroleum ether, acetone, and alcoholic KOH) in the Waring Blendor, followed by centrifugation.

The analytical methods used for moisture, fat, crude fiber, total ash, and phosphorus were essentially those recommended by the Association of Official Agricultural Chemists (1950). (Details of all methods used and modifications of A.O.A.C. methods are on file in this laboratory and will be furnished upon request.) Protein was determined by the Winkler boric acid modifications of the Kjeldahl method (Markley and Hann, 1925).

A modification of the McCrudden method for calcium as recommended by the Human

TABLE 1
COMPOSITION OF PANDANUS FRUIT
(100 grams, Edible portion)

	SAMPLE	WATER	FOOD ENERGY CALORIES*	PROTEIN	FAT	CARBOHYDRATES		ASH	CALCIUM	PHOSPHORUS	IRON
						TOTAL	FIBER				
		gm.		gm.	gm.	gm.	gm.	gm.	mg.	mg.	mg.
1	Lojekerer, fresh	80.20	71	0.37	0.27	18.63	0.28	0.53	9.6	25.9	0.89
2	Lojekerer, boiled	83.74	58	0.22	0.20	15.42	0.08	0.42	13.3	19.6	0.39
3	Joibeb, fresh	84.17	56	0.38	0.27	14.55	0.30	0.63	16.4	33.0	0.58
5	Pandanus paste	17.83	293	2.23	1.38	76.14	3.28	2.42	134.4	108.2	5.74
6	Pandanus flour	10.80	196	2.94	1.25	80.71	14.95	4.30	797.0	114.0	1.73

* Calories, with the exception of those in pandanus flour, were calculated by physiological energy factors recommended for fruit by the U.S.D.A. (Leung, Pecot, and Watt, 1952: 4). For pandanus flour, factors of 1.58, 8.37, and 2.24, respectively, were used for protein, fat, and total carbohydrate by difference. These factors, based on the heat of combustion values for fruit and the digestibility coefficients for wheat bran, were tentatively recommended for use in calculating the calories in pandanus flour by the Human Nutrition Research Branch, Agricultural Research Service (personal communication).

Nutrition Research Branch, Agricultural Research Service, United States Department of Agriculture, was used (personal communication).

Iron was estimated by the Saywell and Cunningham (1937) o-phenanthroline colorimetric method taking all possible precautions in the laboratory to prevent contamination with iron.

COMPOSITION AND NUTRITIVE VALUE

The pandanus products analyzed were: two varieties of fresh and cooked pandanus from the Marshall Islands (Majuro) collected in 1951, one sample of pandanus paste collected in 1949 by Dr. Emory at Mille Atoll, Marshall Islands, and one sample of pandanus flour from Kapingamarangi, also collected by Emory in 1947. The data on composition are summarized in Tables 1 and 2.

Fresh, Raw, and Cooked Pandanus Fruit

The fresh fruit contains but small amounts of protein and fat (less than 0.5 per cent), consequently its greatest food value may be ascribed to its carbohydrate, mineral, and vitamin contents.

The carbohydrate content (14 to 18 per cent) of the edible portion of the fresh pandanus is a little less than raw potatoes, somewhat greater than fresh fruits such as apricots and peaches, and about the same as apples and pears (Watt and Merrill, 1950). The moisture content of 80 to 84 per cent is also similar to these fruits. The edible portion of the fresh, raw pandanus fruit is juicy, whereas the cooked product has much the consistency of a moist, cooked, mashed sweet potato. The fresh samples of Lojekerer and Joibeb were examined and found to contain starch granules which were ruptured in the cooked product and which were easily stained blue with iodine. The starch granules of both varieties were round and relatively small, averaging 9 microns for the Lojekerer variety and 6 microns for Joibeb. The raw juice of the Joibeb

which we examined, obviously contained more starch than the Lojekerer and it also thickened to a greater degree when small samples of the extracted juice were cooked in the laboratory. Whether or not this difference may be explained on the basis of ripeness of the two samples or as a true varietal characteristic, can be determined only by additional tests. The thickening which takes place on cooking can be explained by the presence of the starch grains, but pectins, for which no tests were made, may also be present.

Pandanus fruit contains more calcium than do such temperate climate fruits as apples and peaches, and one sample had as much calcium as fresh apricots and almost as much as orange juice. Our fresh samples of pandanus were equal to or better than white potatoes as a source of calcium but they contained only about half as much calcium as average sweet potatoes. No determinations for oxalates were made and only digestion studies would determine whether or not the calcium is well utilized.

The phosphorus content of pandanus is about the same as that of the fresh fruits listed above but is much less than that of potatoes and sweet potatoes.

The iron content of our fresh samples varied but compares favorably with the fresh temperate climate fruits already mentioned and with potatoes and sweet potatoes.

Pandanus is a good source of provitamin A, the Lojekerer variety being superior to yellow peaches, but not so good as apricots or yellow sweet potatoes. Since the Marshallese, as well as some other island people (Murai, 1954: 14, 186; Spoehr, 1949: 153; Luomala, 1953: 15) consume little if any green and yellow fruits and vegetables, pandanus may constitute the most valuable source of provitamin A in their diet.

Pandanus is at least as good a source of thiamine, riboflavin, and niacin as are apples, peaches, apricots, and pears. It is a less good source of thiamine and riboflavin than potatoes and sweet potatoes. However, there may have been some loss during the period of transportation and storage prior to analysis. Pandanus contains less niacin than white potatoes but more than sweet potatoes, apples, and pears and about the same amount as apricots and peaches.

Both samples of the Joibeb contained approximately twice as much thiamine as the Lojekerer, but the differences in riboflavin and niacin content of the two varieties were small and not consistent for the samples analyzed.

The ascorbic acid content of the boiled sample of pandanus is about four times as great as that of the two fresh samples (Table 2). Possibly inactivation of the enzymes in the cooked sample prior to the long period of transportation and storage may account for

TABLE 2
VITAMIN CONTENT AND *p*H OF PANDANUS FRUIT
(100 grams, edible portion)

SAMPLE	CAROTENE*	THIAMINE	RIBOFLAVIN	NIACIN	ASCORBIC ACID	*p*H
	mcg.	mg.	mg.	mg.	mg.	
1 Lojekerer, fresh	1242	0.031	0.038	0.88	2.3	5.2
2 Lojekerer, boiled	847	0.024	0.034	0.71	8.9	5.1
3 Joibeb, fresh	184	0.052	0.025	0.95	2.6	4.9
4 Joibeb, boiled	291	0.059	0.042	0.73		
5 Pandanus paste	1078	0.037	0.062	2.47	(1.5)	5.6
6 Pandanus flour	1200 I.U.†	0.062	0.156	2.25		5.8

* Total carotenes, chromatographic method.
† Biological determination of vitamin A value with rats.

this. Obviously additional studies are needed to determine the range and typical ascorbic acid values for this fruit.

To determine what proportion of the pandanus keys are usually eaten, 50 children at the Marshall Christian Training School at Ronron cooperated in a simple experiment. A single raw key was given to each student and his name and the weight of the key were recorded. They were asked to eat the pandanus in the usual way and the remaining inedible portion was again weighed.

The weights of single keys ranged from 130 to 200 grams, with an average of 156 grams. The weight of the edible portion ranged from 40 to 102 grams (mostly 60 to 90 grams), with an average of 75 grams. This figure for the weight of the edible portion of a single key has been used for all calculations in Table 3.

TABLE 3
NUTRITIVE VALUE OF THE EDIBLE PORTION OF PANDANUS KEYS

NUTRIENTS	1 KEY 75 GMS.	20 KEYS 1500 GMS.
Calories	53	1060
Protein gm.	.28	5.6
Fat gm.	.20	4.0
Calcium mg.	7.2	144
Phosphorus mg.	19.4	388
Iron mg.	.7	14
Carotene mcg.	932	18,640
Thiamine mg.	.02	.4
Riboflavin mg.	.03	.6
Niacin mg.	.7	14
Ascorbic acid mg.	2	40

While this little study indicates that almost 50 per cent of the key is edible, when the keys were prepared for analyses in the laboratory, the waste was much greater and the edible portion was found to range from 25 to 40 per cent. The edible portion of the cooked product was somewhat greater than the raw. It is probably easier to suck or gnaw out the sweet juice or pulp than to obtain it by mechanical means, and the size and ripeness of the fruit, as well as variety, may influence the proportion of waste.

The dietary study in the Marshall Islands (Murai, 1954) included weekly records of 324 people 1 year of age and over; of this number, 138 ate pandanus, some for only 1 day, others for 6 days out of 7, making a total of 293 days on which pandanus was recorded. The number of large keys consumed ranged from 1 to 25 for all ages. Many ate at least 10 keys and several ate 20, the highest recorded was 25. Children 1 year old ate as many as 10. Records for 18 different days for nine children, 2 and 3 years old, showed that they ate 2 to 10 keys with an average of 5 keys per day.

The nutrients obtainable from one and from 20 keys have been calculated on the basis of our figures for raw Lojekerer and are summarized in Table 3. The conservative value of 3 milligrams of ascorbic acid per 100 grams of edible portion has been used for the calculations in this table although it is highly probable that the value is greater when the pandanus is eaten fresh.

An estimate of the nutritive value of the fresh pandanus may be made by evaluating the contributions to the diet made by 20 keys, which is not at all an unusual quantity, even when a variety of other foods is available. Twenty keys would supply about half the calories needed per day by a small and not very active person, all of the provitamin A, niacin, and iron, about one-third the thiamine, almost half the riboflavin, and more than half the ascorbic acid, judging from the National Research Council's standards or "Recommended Daily Allowances" for all nutrients except calories which are in excess of what the island people would require (Food and Nutrition Board, 1953: 3). Twenty keys would provide little protein, calcium, or fat but would make a good contribution toward the phosphorus needs.

On the basis of our analyses, it is obvious that the greatest contributions of pandanus fruit to the diet are calories, provitamin A, and ascorbic acid. When large amounts are

eaten, the quantities of the three minerals (Ca, P, and Fe) obtained are not inconsiderable but the variety (or varieties) which we analyzed indicate that the edible portion is not an important source of calcium and phosphorus.

It should be emphasized that the groups studied on Uliga Island and Majuro Island, Majuro Atoll, had a rather varied diet and a number of other foods, but in the isolated islets where pandanus, coconut, and fish are often all that is available, half or more of the caloric needs are probably satisfied by pandanus. Coconuts would supply the fat needed and fish and shellfish would furnish not only protein but calcium and phosphorus, especially when small fish are eaten whole.

If the value of about 8 milligrams of ascorbic acid obtained for the cooked sample should prove to be typical of all fresh pandanus, then the fruit would constitute an important source of this vitamin. Even if the pandanus usually has only half this amount, the quantity of ascorbic acid obtained when large amounts are eaten would satisfy the daily needs.

Pandanus Paste

The composition of the pandanus paste may be compared with dried dates which it resembles. The pandanus paste has a little less moisture and therefore a greater energy value (293 calories per 100 grams). The total carbohydrate content is almost identical with dates and the crude fiber content about 1 per cent higher. The reducing sugars of pandanus paste were determined by the Munson-Walker method (Assoc. Off. Agr. Chem., 1950: 506) and found to be 50 per cent (calculated as glucose), which would indicate that about two-thirds of the carbohydrate is in the form of sugars and the remainder includes starch. The protein and fat contents of pandanus paste and dates are low and of little significance. The calcium content of the paste is almost twice that of dates and the phosphorus and iron contents exceed those of dates, though it may well be that some of the iron in the paste is the result of contamination during preparation and drying. The pandanus paste has almost 20 times the vitamin A value of dates, about the same amount of niacin, and less thiamine and ribloflavin. The period of storage prior to the determination of vitamin A was longer than that for the other vitamins as has been indicated. Doubtless all the vitamins were reduced as a result of storage, but since this is a preserved product used for emergencies, the figures which we obtained are probably typical for pandanus paste. Although by the dye titration method pandanus paste had about 1.5 milligrams of ascorbic acid per 100 grams, it may be due to other reducing substances than vitamin C. More work on the paste would be desirable to learn if other samples appear to contain ascorbic acid.

Pandanus Flour

The sample of pandanus flour from Kapingamarangi which was analyzed is probably typical of the dried products made in other islands judging from the description of its preparation given by Grimble (1933–34: 36, 37, 38) for the Gilbert Islands.

Because the entire soft end is cut off and dried as described earlier, no fibers are removed and the resulting "flour," which resembles fine sawdust, is high in crude fiber (15.0 per cent) and low in moisture (10.8 per cent). (The low moisture content is necessary to insure its good keeping quality.) If the crude fiber is calculated to a product containing 80 per cent of water (comparable to the fresh product), the crude fiber would be reduced to approximately 3.3 per cent, which is much greater than that of even our coarsest vegetables such as cabbage. This is in contrast to the pandanus paste which when recalculated to a fresh basis has less crude fiber than the fresh fruit from the Marshalls (Table 1).

Grimble (1933–34: 39), discussing pandanus flour, states that "the gently purgative qualities of the food are also recognized and

valued by the islander, who uses it freely as an aperient for his children." It is to be expected that a food with such a high fiber content would tend to absorb water and form gas, thus lending bulk to the fecal residues and giving it laxative properties. Just how seriously the fiber would interfere with the absorption of food nutrients is difficult to predict. Digestion experiments upon people accustomed to such a coarse diet would be necessary to determine this point. When the pandanus flour is eaten either with water or with concentrated coconut sap as described by Grimble (1933–34: 39), a much greater percentage of crude fiber would probably be ingested than when the fresh raw or freshly cooked pandanus is nibbled and the fibers are rejected or left clinging to the woody end of the keys.

The calcium content of 797 milligrams per 100 grams seems to be remarkably high and when calculated to 80 per cent moisture would still appear high (180 milligrams per 100 grams). Perhaps much of the calcium is in the fibrous portion, but there is also the possibility that a few grains of coral sand, blown into the pandanus flour in the process of making or drying, could raise the calcium to this high value. Additional analyses are desirable to check this figure. The phosphorus and iron contents when calculated to the fresh basis fall within the range for fresh fruit.

The vitamin A value for pandanus flour was determined in 1948 by rat feeding methods employed in our laboratory with standard vitamin A acetate fed to the controls (Miller, *et al.*, 1951: 106). Either the variety from which this sample was made is low in biologically active carotenoid pigments or as a result of oxidation and dessication the vitamin A value is greatly reduced.

The flour retained its riboflavin content remarkably well and appears to have twice as much of this vitamin as does the paste, on a comparable moisture basis. Riboflavin is sensitive to light and it would be expected that losses would be great when a food is dried in the sun. Again the original variety of pandanus used in making the flour no doubt influenced the final product. Niacin, being more stable, appears to have been relatively well retained in the pandanus flour as in the paste.

Pandanus Seeds

By use of a hammer and chisel, a sufficient quantity of pandanus seeds were removed from their woody cases to permit determination of only the moisture, protein, and fat contents, which were 47.2 per cent, 10.1 per cent, and 24.7 per cent respectively. Since one seed weighs about half a gram, and the keys available to us had no more than three or four seeds, and often only one or two, more energy is probably required to extract the seeds than could be obtained from eating them.

SUMMARY AND CONCLUSIONS

In some Pacific islands, especially Kapingamarangi and the Marshall, Gilbert, and Ellice Islands, the pandanus fruit is an important seasonal food.

The soft ends of the keys which form the fruits contain a sweet spicy juice or pulp that is eaten in the raw or cooked state. The edible portion is also preserved in two ways—as a dried paste resembling dried dates and as a "flour."

The fresh raw or cooked pandanus contains 14 to 18 per cent carbohydrate in the form of starch and sugars, but has negligible amounts of protein and fat.

The calcium, phosphorus, and iron contents are comparable to temperate climate fruits such as peaches and apricots.

The carotenoid pigments which give the pandanus a rich yellow orange color may be the only source of provitamin A available to the people of these islands when there are few or no green or yellow vegetables in the diet.

Pandanus, like most fruits, is not a rich source of thiamine and riboflavin, though it makes a significant contribution of these fac-

tors in the diet when eaten in large amounts. This is especially true of riboflavin.

Pandanus is a poor source of ascorbic acid, if compared with fruits rich in vitamin C, but when eaten in relatively large amounts, it could meet the needs of the body for this vitamin.

The composition of pandanus paste and pandanus flour are discussed in relation to the fresh samples. Their special worth lies in their energy value as emergency rations or for long sea voyages.

Our work suggests that additional studies on different varieties, followed by selection and propagation by agriculturists, might be profitable. Planting and continued use of the varieties of highest nutritive value that suit particular areas could well be encouraged by all concerned with the health of the people living in the low dry islands of the Pacific. It is especially important to stress that the edible pandanus should not fall into disuse as the result of introducing "store foods" of low nutritive value.

Acknowledgments

The authors wish to thank a number of people for assistance during the course of this research: Dr. Bruce J. Cooil, Associate Plant Physiologist, Hawaii Agricultural Experiment Station, who assisted in the measurements of the starch grains of pandanus; Miss Helen Denning, former Junior Nutritionist, Hawaii Agricultural Experiment Station, who made most of the analyses for the pandanus paste and pandanus flour under the direction of the senior author; Dr. Kenneth P. Emory, Ethnologist, Bernice P. Bishop Museum, Honolulu, who provided the samples of pandanus paste and pandanus flour and the photograph of the paste in lauhala wrappings; Dr. Harold St. John, Professor of Botany, University of Hawaii, for identification of the pandanus varieties; Mr. Horace Clay, Assistant Specialist in Horticulture, Agricultural Extension Service, University of Hawaii, for collecting and transporting the pandanus fruit shown in Figure 1, and Mr. Yoshihiko Kawano, Assistant in Chemistry, H.A.E.S., for taking the photograph; Dr. Leonard Mason, Professor of Anthropology, University of Hawaii, who loaned the beka shown in Figure 3.

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Some Unusual Fishes From the Central Pacific

JOSEPH E. KING and ISAAC I. IKEHARA[1]

THE PURPOSE OF THIS ARTICLE is to call the attention of ichthyologists to certain rare or uncommon fishes recently collected in the central Pacific by staff members of the Pacific Oceanic Fishery Investigations at Honolulu, and others. These fishes have been deposited with the U. S. National Museum. The photographs included here were taken by E. D. Stroup; Figure 4 was prepared by Tamotsu Nakata.

SQUALIDAE

The first two species, here placed in the Squalidae following Hubbs and McHugh (1951), were formerly placed in the Dalatiidae, e.g. Bigelow and Schroeder (1948).

1. **Euprotomicrus bispinatus** (Quoy and Gaimard)

One female specimen (Fig. 1) (USNM No. 164176), 161 mm. in total length. Collected March 3, 1948, about 340 miles WNW of Johnston Island at 18°24′N., 175°12′W. in water about 1,000 fathoms deep. Attracted to a light and dip-netted at surface. Collected by M. B. Schaefer aboard M/V "Oregon" operated by Pacific Exploration Company.

Description: No anal fin; 2 dorsal fins without spines; snout blunt and broadly rounded; 5 gill openings, all anterior to pectorals; body nearly cylindrical; eyes lateral without nictitating membrane; a large spiracle present; mouth transverse with a groove extending posteriorly from each end; teeth with only 1 cusp and not serrated; upper teeth narrowly triangular and needle-pointed, lower teeth broader, compressed, and bent outwards; caudal axis scarcely upturned; no subterminal notch evident; end of base of first dorsal fin well in advance of the pelvic insertion; base of second dorsal fin very much longer than that of the first; denticles quadrate, with a central pit; first dorsal fin very much nearer pelvic base than pectoral base; body uniform brownish black (in alcohol after fixation in formalin), outer edges of fins clear. Measurements of the specimen and proportional measurements as per cent of total length are given in Table 1.

Hubbs and McHugh (1951) report the capture of a female *E. bispinatus*, 233 mm. total length, about 500 miles off the California coast. They give a thorough description of the specimen and state that it is ". . . the only extant example of the genus known from the Pacific Ocean and, so far as we know, the only one in an American museum." An earlier specimen collected in the open Pacific "between Honolulu and San Francisco, but nearer to the former" (Eigenmann, 1891) was destroyed in the San Francisco fire, according to Hubbs and McHugh. Since we can find no record of any capture of this species since

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TABLE 1

BODY MEASUREMENTS AND PROPORTIONAL MEASUREMENTS OF *Euprotomicrus bispinatus* AND *Isistius brasiliensis*
(Body Measurements in Millimeters, Proportional Measurements [bracketed] in Percentage of Total Length)

	*E. bispinatus**	*I. brasiliensis*†
Trunk at origin of pectoral: breadth	19.0 (11.8)	21.0 (11.1)
height	17.0 (10.6)	19.5 (10.3)
Snout length in front of: outer nostrils	3.0 (1.9)	1.5 (0.8)
mouth	17.0 (10.6)	13.0 (6.9)
Eye: horizontal diameter	6.0 (3.7)	8.0 (4.2)
Mouth: breadth	11.0 (6.8)	10.5 (5.6)
height	1.0 (0.6)	0.0 (0.0)
Nostrils: distance between inner ends	4.0 (2.5)	3.0 (1.6)
Labial furrow length from angle of upper jaw	8.0 (5.0)	11.0 (5.8)
Gill opening lengths: 1st	2.0 (1.2)	2.0 (1.1)
2nd	2.0 (1.2)	2.0 (1.1)
3rd	2.0 (1.2)	2.0 (1.1)
4th	1.5 (0.9)	1.5 (0.8)
5th	1.0 (0.6)	1.0 (0.5)
First dorsal fin: vertical height	2.5 (1.6)	4.0 (2.1)
length of base	2.5 (1.6)	6.0 (3.2)
Second dorsal fin: vertical height	3.3 (2.0)	4.0 (2.1)
length of base	14.0 (8.7)	7.0 (3.7)
Caudal fin: upper margin	25.0 (15.5)	27.0 (14.3)
lower anterior margin	20.0 (12.4)	20.0 (10.6)
Pectoral fin: outer margin	16.5 (10.2)	16.0 (8.5)
inner margin	10.5 (6.5)	11.0 (5.8)
distal margin	13.0 (8.1)	6.8 (3.6)
Distance from snout to: 1st dorsal	84.0 (52.2)	115.5 (61.1)
2nd dorsal	108.0 (67.1)	136.5 (72.2)
upper caudal	137.0 (85.1)	164.0 (86.8)
pectoral	40.0 (24.8)	42.0 (22.2)
ventrals	94.0 (58.4)	122.5 (64.8)
Interspace between: 1st and 2nd dorsals	21.0 (13.0)	16.7 (8.8)
2nd dorsal and caudal	16.0 (9.9)	20.5 (10.8)
Distance from origin to origin of: pectoral and ventrals	56.5 (35.1)	84.5 (44.7)
ventrals and caudal	41.0 (25.5)	41.0 (21.7)

* Female, 161 millimeters in total length.
† Female, 189 millimeters in total length.

1951, we believe that our specimen is the third example of the genus (monotypic) known from the Pacific and the second example in an American collection.

2. **Isistius brasiliensis** (Quoy and Gaimard)

One male specimen (USNM No. 164173), 165 mm. in total length. Collected March 2,

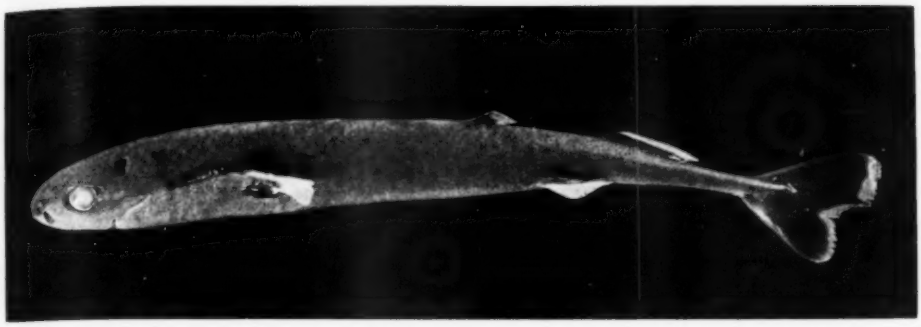

FIG. 1. Lateral view of a 161 millimeter (female) *Euprotomicrus bispinatus* captured at the surface with a dip net at 18°24′N., 175°12′W.

FIG. 2. Lateral view of a 189 millimeter (female) *Isistius brasiliensis* captured by pelagic trawl at 2°09′N., 158° 14′W.

1952, at about 11 P.M. aboard M/V "Hugh M. Smith" at 2°04′S., 168°57′W., in water about 3,000 fathoms deep. Collected by Heeny Yuen employing a 1-meter (mouth diameter) zooplankton net in an oblique haul to 200 meters depth.

A female specimen (USNM No. 164175), 179 mm. in total length. Collected May 23, 1954, at about 8:30 P.M. aboard M/V "John R. Manning" at 4°47′N., 161°04′W., in water about 2,000 fathoms deep. Collected by J. E. King and T. S. Hida in a 6-foot Isaacs-Kidd trawl; depth of haul about 100 meters.

A second female (Fig. 2) (USNM No. 164174), 189 mm. in total length. Collected June 2, 1954, at about 8:30 P.M., aboard M/V "John R. Manning" at 2°09′N., 158°14′W., in water about 1,000 fathoms deep. Collected by J. E. King and T. S. Hida in a 6-foot Isaacs-Kidd trawl with depth of haul about 100 meters. Measurements of this specimen are given in Table 1.

Description: No anal fin; 2 dorsal fins, without spines; snout blunt and broadly rounded; 5 gill openings, all anterior to pectorals; body nearly cylindrical; eyes lateral, without nictitating membrane; a large spiracle present; teeth with only 1 cusp and faint indications of serration; teeth of the upper and lower jaw very unlike, the upper are slender and curved

outwards while the lower are much larger and erect, with subquadrate bases and triangular sharp-pointed cusp; caudal axis scarcely upturned; subterminal notch in caudal fin slight; mouth transverse, with fleshy lips and a groove extending backwards and outwards from each end; unlike *E. bispinatus*, the first dorsal fin is displaced backward so that the end of its base is over the origin of the pelvic base; dorsal fin bases nearly equal; denticles quadrate with a median pit; first dorsal fin very much nearer pelvics than pectoral base; body dark brown above (in alcohol after fixation in formalin), pale grayish brown below except for a dark collar across the throat; fins with outer edges clear except the upper lobe of the caudal, which is brown to the margin.

This small oceanic shark, although uncommon, is not nearly as rare as *E. bispinatus*. According to Bigelow and Schroeder (1948), *I. brasiliensis* is distributed throughout the tropical and subtropical belts of all three oceans; however, records of its occurrence in the eastern and central Pacific are few. One specimen was taken by the "Albatross" (Garman 1899) at 2°34′N., 92°06′W. F. D. Bennett (1840) captured two specimens, which he classified as *Squalus fulgens*, in a net towed at the surface; one of these, 10 inches in length, he reported as taken at 2°30′S., 163° W., and the other, 18 inches in length, at 55°N., 110°W. Garman (1899) pointed out the obvious error in the latter position and stated that the actual longitude was 140°W. Later G. Bennett (1860) collected a 5.5-inch specimen, which he classified as *Scymmus* sp., at 2°15′S., 163°W. Jordan and Jordan (1922) report the occurrence of this small shark in Hawaiian waters under the name *Apristurus spongiceps* (Gilbert). Fowler and Ball (1925) state that a specimen classified earlier (Fowler 1923) as *Echinorhinus brucus* (Bonnaterre) in Bernice P. Bishop Museum collections from Hawaiian waters is actually *I. brasiliensis*. All the above names are placed in synonymy with *I. brasiliensis* by Bigelow and Schroeder (1948).

The Bennetts' description of the luminiscence of this fish has been quoted often. This characteristic was not observed in our three specimens, possibly because all three were dead when brought on deck. The luminiscence is reported to fade out as the fish dies.

LOPHOTIDAE

3. **Eumecichthys fiski** (Günther) Regan

One specimen (Figs. 3 and 4) (USNM No. 164170), 598 mm. in standard length. Collected June 1, 1954, at about 12:15 P.M. aboard M/V "John R. Manning" at 3°04′N., 159°13′W., in water about 900 fathoms deep. Dip-netted at the surface by Howard Kamauu, fisherman on the "Manning."

Description: Body elongate, strongly compressed, nearly of uniform depth throughout, scaleless, snout prolonged as a sword-shaped process bearing near its tip a pronounced plume or crest (Fig. 3); dorsal fin commences at the tip of this process with an extremely long and compressed ray, then continues to the caudal averaging in height about one-fourth the body depth; both jaws are armed with small, hooked teeth; premaxillary nonprotractile; eye large; no ventral fins; anal fin rudimentary, base about 3 mm., height less than 1 mm. (Fig. 4); body silvery (in alcohol after fixation in formalin) with about 30 dark bars or blotches, most prominent dorsally; occipital crest and dorsal and caudal fins were crimson in life but faded completely in formalin.

Fin ray count: D. 326; P. 13(R), 12(L); C. 10.

Body measurements (in millimeters) and proportional measurements (bracketed) as percentage of standard length: snout to vent, 579.0 (96.7); vent to base of caudal, 20.5 (3.4); caudal fin length, 25.5 (4.3); head length including snout, 64.0 (10.7); snout length in front of mouth, 30.0 (5.0); snout to origin of pectoral, 64.0 (10.7); greatest body height, 21.3 (3.6); greatest body breadth, 7.0 (1.2); pectoral fin length, 13.0 (2.2); pectoral fin base, 5.0 (0.8); dorsal fin height at mid-point of body, 6.0 (1.0); dorsal fin

FIG. 3. Head portion of a 625 millimeter specimen of *Eumecichthys fiski* captured at the surface in a dip net at 3°04′N., 159°13′W.

height at origin of pectoral, 4.0 (0.7); dorsal fin height above vent, 5.0 (0.8); crest height, 83.0 (13.9); eye diameter, 8.0 (1.3).

Details of the capture of this rare fish are perhaps of interest. About midday shortly after starting to haul longline, we (J. E. King and T. S. Hida) noticed a thin "shadow" near the surface just to the rear of the point where the line was emerging from the water. When we finally decided that this was not just the wake or the shadow of the line but an unusual object in the water, a dip net was hastily obtained and this very rare fish was scooped from the water. After it had lain on a canvas hatch cover for a few minutes, we noticed that a black fluid had been discharged from the vent. Kershaw (1909) and Griffin (1934) have reported that lophotid fishes may emit an inky fluid from the vent when captured.

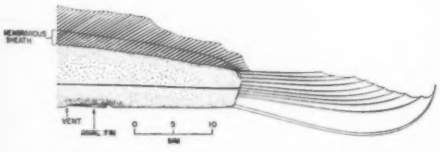

FIG. 4. Tail portion of *Eumecichthys fiski*, same specimen as in Figure 3, with the caudal fin expanded to show the detailed structure of the fin.

Eumecichthys fiski was described by Günther (1890) as *Lophotes fiski* from a 50-inch specimen that washed up on the shore of Kalk Bay (Atlantic Ocean), South Africa. In this fish the caudal region was mutilated so that Günther did not know the nature of the caudal fin nor whether or not an anal fin was normally present. Apparently no additional examples had appeared in South Africa by the time of the recent revision of "The Sea Fishes

of South Africa" by Smith (1953). From our examination of available literature, we conclude that all subsequent collections of *E. fiski*, except for our specimen from the central Pacific, have been from Japanese waters. Kamohara (1949) states that "In Japan a specimen 88.1 cm. in length was collected off Kōchi in 1939 by a worker from the Kōchi Prefectural Fisheries Experiment Station and was reported by Dr. Kiyomatsu Matsubara. This was the first record from Japan. Thereafter it transpired that several specimens had been captured in 1937 off Hagi in Yamaguchi Prefecture, and that it had also been collected earlier in Wakayama Prefecture." [Translated from the Japanese by W. G. Van Campen.] There is no reference to this species in *The Fishes of Oceania* (Fowler, 1928) and its supplements, or in *The Fishes of the Indo-Australian Archipelago*, Vol. V (Weber and De Beaufort, 1929), which includes the Allotriognathi.

TRACHYPTERIDAE

4. ? **Trachypterus iris** (Walbaum)

Two specimens (USNM No. 164172), both juveniles; one 84 mm. in standard length (caudal fin broken), the other 109 mm. in standard length (146 mm. total length with caudal depressed to the horizontal). Collected May 4, 1953, at about 8 P.M. aboard M/V "John R. Manning" at 8°32′N., 150°12′W., in water about 2,700 fathoms deep. Collected by W. F. Royce and W. M. Matsumoto in a 10-foot Isaacs-Kidd trawl; depth of haul about 200 meters.

Description: Body elongate, strongly compressed, scaleless; dorsal fin extends length of body; caudal fin divided, the larger portion pointing upwards; rays of dorsal bear numerous spinules; lateral line spinous; vent located on mid-ventral line in contrast to the following species; anterior profile steep, almost vertical; mouth protractile; body pale colorless (in alcohol after fixation in formalin).

Fin ray count: D. 160 ± 2; P. (broken); V. 5; C. 7 (upper), 5 (lower).

Body measurements (in millimeters) and proportional measurements (bracketed) as percentage of standard length (109 mm.): snout to vent, 70.0 (64.2); vent to base of caudal, 42.0 (38.5); caudal fin length, 34.0 (31.2); greatest body height, 18.0 (16.5); greatest body breadth, 6.0 (5.5).

5. ? **Trachypterus woodi** Smith

One specimen (Fig. 5) (USNM No. 164 171), a juvenile, 113 mm. standard length (125 mm. in total length with caudal depressed to the horizontal). Collected May 25, 1954, at about 8:30 P.M. aboard M/V "John R. Manning" at 4°41′N., 159°53′W., in water about 2,000 fathoms deep. Collected by J. E. King and T. S. Hida in a 6-foot Isaacs-Kidd trawl; depth of haul about 100 meters.

Description: Body strongly compressed; dorsal fin extends length of body; rays of dorsal with numerous spinules, each ray with a pair of larger spines near its base; rays at anterior end of dorsal show evidence of having been prolonged but are now broken; anterior profile steep but less than vertical; body covered with small, smooth tubercles, particularly prominent in the ventral region; lateral line spinous; no anal fin; caudal fin turned upwards, with no downward projecting portion as in previous specimen; vent located on left side of body about 2 mm. above mid-ventral line (the asymmetrical location of vent in *T. misakiensis* was pointed out by Herre and Herald in 1950); body silvery (in alcohol after fixation in formalin) with scattered dark blotches below dorsal and perhaps seven small blotches extending posteriorly in a line beginning at the upper margin of the eye; fins pink in life, clear in alcohol.

Fin ray count: D. 144, P. 12, V. 9, C. 8.

Body measurements (in millimeters) and proportional measurements (bracketed) as percentage of standard length: snout to vent, 78.5 (69.5); vent to base of caudal, 34.0 (30.0); caudal length, 12.5 (11.0); head length, 22.0 (19.4); eye diameter, 7.3 (6.4); snout to origin pectorals, 19.0 (16.7); snout to origin ven-

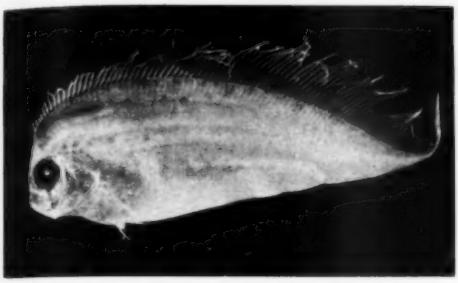

FIG. 5. Lateral view of ?*Trachypterus woodi* Smith captured by pelagic trawl at 4°41′N., 159°53′W.

trals, 23.0 (20.3); greatest body height, 38.0 (33.5); greatest body breadth, 8.0 (7.0); greatest height of dorsal fin, 18.0 (15.9).

Most of the trachypterids examined by ichthyologists have been washed up on shore and usually were in poor condition; our specimens are among the few to be collected in nets, and one of the three, at least, is in excellent condition. These fishes are noted for their change in body proportions during development after the postlarval period (Hubbs, 1926). The juveniles are particularly difficult to identify. On the basis of available literature we have decided that two of our specimens are most likely *T. iris* (Walbaum), which is principally a Mediterranean species, whereas the third resembles *T. woodi* Smith. Although the identification is not certain due to limited library facilities and lack of sufficient reference material, our description, measurements, and the accompanying figure may provide some worthwhile information to those who are interested in the life history of these unusual fishes.

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Some Marine Algae of the Southern Marshall Islands[1]

E. YALE DAWSON[2]

NO RECORDS OF MARINE ALGAE from the southern atolls of the Marshall Islands have heretofore appeared in the literature. Indeed, our only account of the marine vegetation of this far-flung archipelago is that by W. R. Taylor (1950) dealing with Bikini and other northern atolls of the group.

A recent opportunity to visit several of these atolls with a field team under the leadership of Dr. Bruce W. Halstead resulted in the gathering of a considerable collection of algae from Kwajalein, Jaluit, and Majuro atolls[3]. To this has been added, through the kindness of Dr. M. S. Doty of the University of Hawaii, a large collection obtained by Mr. Leonard Horwitz on Arno Atoll[4].

These combined collections are so numerous that time has not yet permitted a study of all of the material. What is given here is an annotated list of those specimens which have been examined to date, exclusive of a number of apparently undescribed species and of certain other plants in need of more critical study. It is hoped that a second part may soon be added to complete this account.

As an aid to field workers who may not have a large algological library at their disposal, an attempt has been made to provide an illustration for each species of which one may not otherwise be at hand. Two handbooks are considered to be so readily available as to serve in conjunction with this paper, namely, Taylor's 1950 account mentioned above, and the writer's recent, fully illustrated treatment of the tropical marine algae of Viêt Nam which appeared in *Pacific Science* Vol. 8, No. 4, 1954. Thus, an illustration is presented here wherever one is not to be found for a given species in one or the other of these works. The style of presentation is the same as in the latter paper. I was aided in the preparation of the drawings by Mrs. Glennis Sayers Clements. The photographs were prepared by Mr. Royford George.

The specimens are cited here by field number preceded by "D." or "H." The former denotes the writer's collections which are deposited in his personal herbarium. The latter denotes those of Mr. Horwitz which are deposited in the Bernice P. Bishop Museum at Honolulu.

LIST OF STATIONS

The following station numbers are assigned arbitrarily and are not chronological. They serve to provide general locality information

[1] Contribution No. 163 from the Allan Hancock Foundation. Manuscript received May 6, 1955.

[2] Formerly Associate Professor of Biology in the Allan Hancock Foundation, University of Southern California, Los Angeles.

[3] This field work was sponsored in part by a research grant from the National Institute of Health, United States Public Health Service, Bethesda, Maryland, to the School of Tropical and Preventive Medicine, College of Medical Evangelists, Loma Linda, California.

[4] This collection was obtained with financial assistance granted by the Pacific Science Board of the National Academy of Sciences, National Research Council, under contract N7onr-291, Task Order IV, from the Office of Naval Research and a grant from the Pacific Islands Research funds of the University of Hawaii.

on the collections which are cited also by individual field number in the text.

Kwajalein Atoll

Sta. 1. North end of Kwajalein Island along the seaward side of the reef at low tide, Sept. 26, 27, 1954.

Sta. 2. Along the lagoon side of the reef in the vicinity of the first islet north of Kwajalein Island, in up to 1 m. of water at low tide, Sept. 27, 1954.

Sta. 3. Beach drift along seaward reef of north end of Kwajalein Island, Sept. 26, 1954.

Sta. 4. Beach drift along lagoon shore of west end of Kwajalein Island, Sept. 26, 1954.

Sta. 5. Reef at north end of Kwajalein Island at low tide, Oct. 12, 1954.

Majuro Atoll

Sta. 6. On the broad, seaward reef-flat of Uliga Island at low tide, Oct. 10, 12, 1954.

Sta. 7. Along the seaward coralline algal ridge of Uliga Island at low tide, Oct. 10, 1954.

Sta. 8. On the broad seaward reef flat at the northeast end of Dalap Island at low tide, Oct. 11, 1954.

Sta. 9. Narrow seaward reef at east end of Rairikku Island at low tide, Oct. 11, 1954.

Sta. 10. Narrow seaward reef at west end of Enierripu Island at low tide, Oct. 11, 1954.

Sta. 11. Lagoon side of Uliga Island opposite the staff dwellings, Oct. 10, 1954.

Jaluit Atoll

Sta. 12. Seaward edge of reef at Jabor, Jaluit Island, near the old meteorological station at low tide, Sept. 28, 1954.

Sta. 13. From 2–5 meter depths at Sydney Pier, Jaluit Island, Sept. 29, 1954.

Sta. 14. Beach drift along sea wall at Jabor, Jaluit Island, Oct. 2, 1954.

Sta. 15. Along the lagoon side of Kabenbock Island at low tide, Sept. 29, 1954.

Sta. 16. Along the ocean side of Kabenbock Island opposite the pass, mostly in the shelter of an old shipwreck, at low tide, Sept. 29, 1954.

Sta. 17. In 1–2 meter depths in the bombed out docking area at Jabor, Jaluit Island, at low tide, Sept. 30, 1954.

Sta. 18. Under edges of rocks at medium tide levels and above, lagoon side of Elizabeth Island near the pass, Oct. 1, 1954.

Sta. 19. Edge of the reef of Kabenbock Island along the pass in 1–2 meter depths at low tide, Oct. 3, 1954.

Sta. 20. Patch reef west of Sydney Pier in depths of 2–5 meters at low tide, Oct. 3, 1954.

Sta. 21. Seaward reef, Jaluit Island in vicinity of Jabor, at +2.0–3.0′ tide levels, Oct. 4, 1954.

Sta. 22. Lagoon side of Jaluit Island near Sydney Pier, at +2.0–4.0′ tide level, in shaded places under overhanging trees, Oct. 4, 1954.

Sta. 23. Enybor Island, a few hundred meters inside the channel, in 1–3 m. depths at low tide, Oct. 7, 1954.

Arno Atoll

The extensive collections of Mr. Leonard Horwitz at Arno Atoll as a member of the Pacific Science Board's 1951 coral atoll team, were made largely in the vicinity of Ine village on Ine Island along the south side of the atoll from late June until late August 1951. Inasmuch as the collection stations on Ine were very numerous they will not be itemized here but treated only as to "Ocean side" or "Lagoon side" of the island. Additional information may be obtained by consulting Mr. Horwitz' original field notebook, a microfilm copy of which is deposited with the Bernice P. Bishop Museum, Honolulu.

Sta. 24. Ocean side of Ine Island, June–August 1951.

Sta. 25. Lagoon side of Ine Island, June–August 1951.

Sta. 26. Ocean side of eastern tip of Tinak Island, August 5, 1951.

Sta. 27. Sandy bottom of lagoon flat off Malel Island, August 4, 1951.

Sta. 28. Lagoon shore of Eonëb-je Island, June–August 1951.

Sta. 29. Upper half of reef pavement of western end of Boki, August 18, 1951.

SYSTEMATIC LIST

Enteromorpha compressa (L.) Greville 1830: 180, pl. 18; Setchell and Gardner 1920: 251, pl. 14, figs. 7–8, pl. 16, fig. 3; Bliding 1948: 128, figs. 5–9. *Ulva compressa* Linnaeus 1755: 433 (Sweden)
Fig. 1

MAJURO ATOLL: D. 12769, Sta. 10. This is a short form but apparently typical, agreeing well with both the recent accounts cited above.

FIG. 1. *Enteromorpha compressa:* Habit sketch of a thallus, × 1.

FIG. 2. *Enteromorpha ralfsii:* Part of a filament of D. 12658, × 50.

Enteromorpha kylinii Bliding 1948: 1, figs. 1–3 (West coast of Sweden); Dawson 1954: 384, fig. 5

KWAJALEIN ATOLL: D. 12658b, Sta. 5.
MAJURO ATOLL: D. 12728, 12740, Sta. 7.
JALUIT ATOLL: D. 13153a, Sta. 21. This material is small and short, but structurally agrees well with this species.

Enteromorpha ralfsii Harvey 1851: pl. 282 (Wales); Hamel 1931: 59, fig. 46d
Fig. 2

KWAJALEIN ATOLL: D. 12658, Sta. 5. The filaments of this material are capillary, essentially simple, about 40 μ in diameter, and composed of only 3 or 4 rows of cells.

Enteromorpha clathrata (Roth) J. Agardh 1883: 153; Bliding 1944: 331, figs. 5–7; Dawson 1954: 384, fig. 6d, e. *Conferva clathrata* Roth 1806: 175 (Baltic Sea)

JALUIT ATOLL: D. 13072, Sta. 15. This is Bliding's Typus II of this variable species. Uniseriate branches are abundant as in the Vietnamese material cited.
ARNO ATOLL: H. 9678, Sta. 25.

Halicystis pyriformis Levring 1941: 612, fig. 3 L–P (Juan Fernandez Islands); Dawson 1954: 388, Fig. 8a–c

JALUIT ATOLL: D. 13009, Sta. 12. These are in good agreement in all respects. The largest vesicles are 4 mm. high.

Valonia aegagropila C. Agardh 1822: 429 (Venice, Italy); Taylor 1950: 41; Dawson 1954: 388, fig. 8j

KWAJALEIN ATOLL: D. 12567, Sta. 1; D. 12626, Sta. 2; D. 12662, Sta. 5.

MAJURO ATOLL: D. 12747, Sta. 8.

ARNO ATOLL: H. 9333b, 9392a, Sta. 26; H. 9630, Sta. 24.

Valonia ventricosa J. Agardh 1887: 96 (St. Croix, Virgin Islands); Dawson 1954: 388, fig. 8e

KWAJALEIN ATOLL: D. 12609, Sta. 2.

JALUIT ATOLL: D. 13056, Sta. 13; D. 13124a, Sta. 19. Plants were abundant in these localities and often 5–6 cm. in diameter.

ARNO ATOLL: H. 9491a, Sta. 28. A few very small plants only 2–3 mm. high, but with the characteristic basal attachment cells.

Valonia utricularis (Roth) C. Agardh 1822: 431; Taylor 1950: 41. *Conferva utricularis* Roth 1797: 160, pl. 1, fig. 1 (Mediterranean Sea)

Fig. 3

JALUIT ATOLL: D. 13122, Sta. 19. The specimen is apparently typical, agreeing with Roth's original figures of dry specimens, poor as they are.

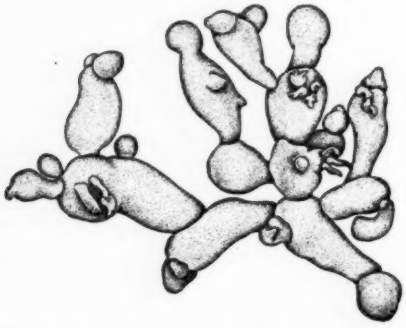

FIG. 3. *Valonia utricularis:* A plant of D. 13122 as seen from the under side, × 2.

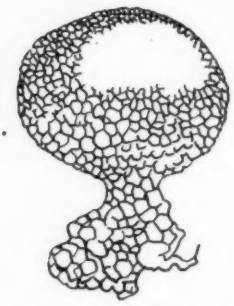

FIG. 4. *Dictyosphaeria bokotensis:* Reproduction of Yamada's original illustration of a specimen of the type collection, × 2.

Dictyosphaeria bokotensis Yamada 1925: 81, fig. 1 (Pescadores Islands, Formosa)

Fig. 4

KWAJALEIN ATOLL: D. 12596a, Sta. 1. This collection includes but two specimens, both imperfect from the breaking away of the dome of the hollow thallus. The abundance of long, intracellular spines (trabeculae) and the uniformly small cells of the upper parts of the hollow plants are distinctive. Yamada reports this species from Ant Atoll in the Caroline Islands.

Dictyosphaeria intermedia var. **solida** Nasr 1944: 32 (Ghardaqa, Red Sea); Nasr 1947: 29, pl. 1, fig. 1; Taylor 1950: 42 (as *D. intermedia* Weber van Bosse)

Fig. 5

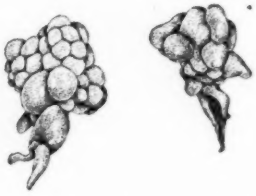

FIG. 5. *Dictyosphaeria intermedia* var. *solida:* Two young specimens from D. 12635, × 2.

KWAJALEIN ATOLL: D. 12635, Sta. 2; D. 12557, D. 12596, Sta. 1.

JALUIT ATOLL: D. 13017, Sta. 12.

ARNO ATOLL: H. 9390b, Sta. 26.

Young specimens of our collections correspond closely with Nasr's plant which came from a similar habitat "on the edges of dead corals in places exposed to strong waves and firmly adhering to the substratum by basal rhizoids." In most of the specimens of later stages an irregular development of cavernous invaginations takes place in the gregarious thalli, but hardly the development of a hollow structure in the sense of Weber van Bosse's type plants (1905: 143). Taylor does not speak of his northern Marshall Island specimens as being hollow, but that "it is not infrequent for the organization of the coenocyte into solid thalli to be irregular, even loose, and in such cases the cells are large." On the other hand, D. 12596 includes some examples in which the inner breakdown to the hollow condition has occurred, and which would correspond with *Dictyosphaeria intermedia* var. *intermedia* W. van B. Others are solid like Nasr's plant.

This is probably the plant redescribed by Yamada (1944*a*) as *D. mutica*.

Dictyosphaeria versluysii Weber van Bosse 1905: 144 (Indonesia); Dawson 1954: 388, fig. 8k, l

KWAJALEIN ATOLL: D. 12560, Sta. 1.

ARNO ATOLL: H. 9265a, Sta. 24; H. 9392, Sta. 26.

Dictyosphaeria cavernosa (Forsk.) Børgesen 1932: 2, pl. 1, fig. 1; Taylor 1950: 43, pl. 27, fig. 2; Dawson 1954: 388, fig. 8i. *Ulva cavernosa* Forskål 1775: 187 (Red Sea)

MAJURO ATOLL: D. 12687, Sta. 6; D. 12719, Sta. 6 (fragmentary material of the large, coarse, flat form illustrated by Taylor); D. 12764, Sta. 9.

JALUIT ATOLL: D. 13083, Sta. 16; D. 13104, Sta. 18.

ARNO ATOLL: H. 9343, Sta. 27; H. 9599b, Sta. 25; H. 9493a, sandy floor of lagoon reef off Matal-En. The large, flat form.

The majority of the specimens of these collections represent the small, hollow, reef-flat form which is almost identical with the Vietnamese plant illustrated by Dawson 1954.

Boodlea vanbosseae Reinbold 1905: 148 (Lucipara Island, Indonesia); Reinbold, in Weber van Bosse 1913: 70, fig. 12

Fig. 6

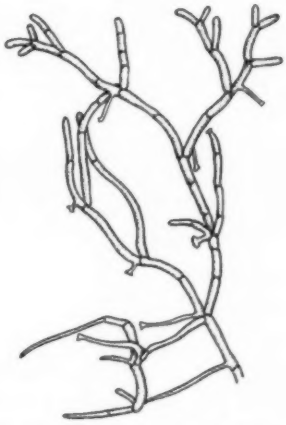

FIG. 6. *Boodlea vanbosseae:* Part of a plant teased out of a clump from H. 9330, showing the rhizoidal branches and fibulae, × 7.

ARNO ATOLL: H. 9330, H. 9372a, Sta. 26; H. 9343a, H. 9373b, H. 9374, Sta. 27. This material is manifestly like that described and illustrated by Reinbold. The filaments are 200–300 μ in diameter and are provided with abundant rhizoidal branches. The haptera, or fibulae, which may be frequent or rather few, arise directly from the ends of cells without the formation of a cross wall except in rare instances.

Yamada (1925: 87) illustrates a plant from Formosa which shows great resemblance to this species and described it as *Cladophora montagnei* Kützing var. *radicans* Yamada. Although he shows none of the fibulae char-

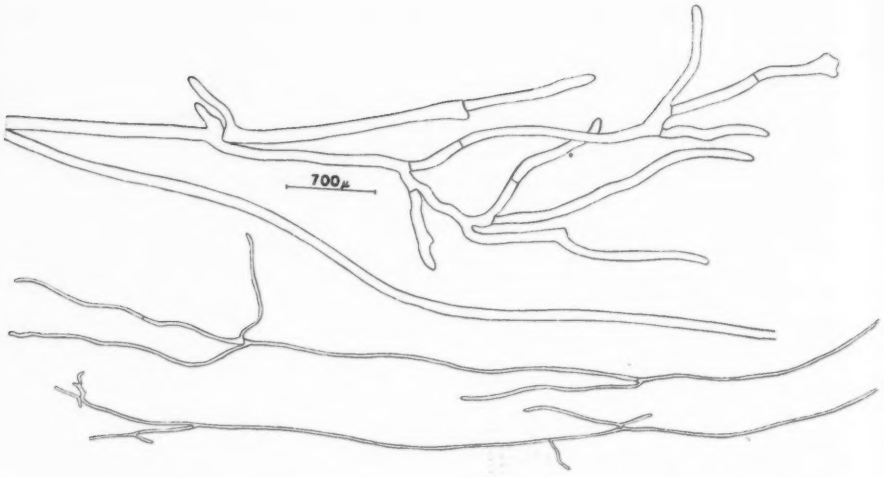

FIG. 7. *Cladophoropsis gracillima:* Reproduction of original illustration of plants of the type collection from Mexico. *a*, Terminal portion of a branched filament showing the manner of septation of branches; *b*, small portion of a skein-like plant to show the extremely long cells and infrequent branching, × 8.

acteristic of *Boodlea*, the habit, size, cell shape and rhizoids strongly suggest identity with *Boodlea vanbosseae*.

Boodlea composita (Harv.) Brand 1904: 187; Taylor 1950: 44; Dawson 1954: 390, fig. 9c, d. *Cladophora composita* Harvey 1834: 157 (Mauritius)

KWAJALEIN ATOLL: D. 12587, Sta. 1 (a slender form with ultimate branches only 70 μ or less in diameter; D. 12613, Sta. 2; D. 12649, Sta. 3; D. 12659, Sta. 4.

MAJURO ATOLL: D. 12698, 12701, Sta. 6.

JALUIT ATOLL: D. 13106, Sta. 18; D. 13139, Sta. 20.

ARNO ATOLL: H. 9493c, Sta. 28; H. 9581c, Sta. 25.

Struvea anastomosans (Harv.) Piccone and Grunow, ex Piccone 1884*a*: 20; Dawson 1954: 390, fig. 8g. *Cladophora ? anastomosans* Harvey 1859, pl. 101 (Fremantle, West Australia)

KWAJALEIN ATOLL: D. 12603, Sta. 2; D. 12671, Sta. 5.

JALUIT ATOLL: D. 13047, Sta. 13.

Cladophoropsis gracillima Dawson 1950*a*: 149, figs. 12–13 (Punta Palmilla, Baja California, Mexico)
Fig. 7

ARNO ATOLL: H. 9327, H. 9333a, Sta. 26. This material, with its very long cells and thick, stratified cell walls (often 10 μ or more) is identical with the type of this tropical Mexican species. The filaments are mostly 70–100 μ in diameter and remotely branched and septate except in the outer parts of some filaments which are septate much as shown in Dawson's figure reproduced above. This species has heretofore been known only from the type material.

Cladophoropsis sundanensis Reinbold 1905: 147 (Timor); Reinbold, in Weber van Bosse 1913: 77, fig. 18; Dawson, Aleem and Halstead 1955: 10
Fig. 8

KWAJALEIN ATOLL: D. 12593, Sta. 1.

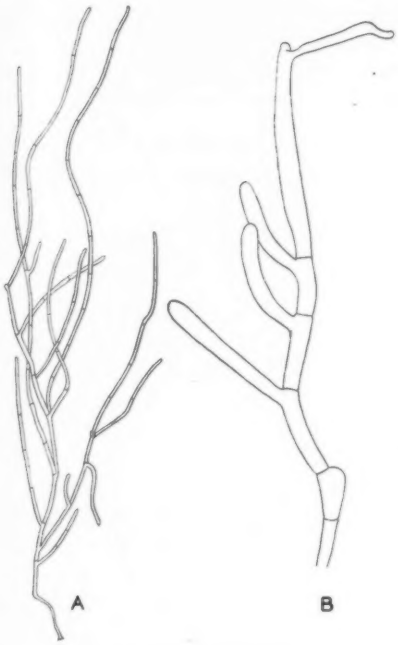

FIG. 8. *Cladophoropsis sundanensis: a*, Habit of part of a plant of D. 12712, × 7.5; *b*, detail of branching of part of a plant of D. 12593, × 20.

MAJURO ATOLL: D. 12699, 12711, Sta. 6; D. 12712, 12714, in abundant, large mats along the lagoon shore of Dalap Island. This slender, laxly branched form is most probably the same as the plant attributed to *Cladophoropsis zollingeri* by Taylor (1950). While the diameter of *C. sundanensis* ranges from about 60 to 130 μ, or sometimes to 175 μ, *C. zollingeri* is a coarser plant in which the type specimen according to Howe (1914) has filaments 215–315 μ in diameter.

JALUIT ATOLL: D. 13012, Sta. 12.

ARNO ATOLL: H. 9490, Sta. 28. The filaments in these are mostly 80–90 μ in diameter; the occurrence of septa at the base of lateral branches is not infrequent, although in most instances the characteristic *Cladophoropsis* type of branching obtains.

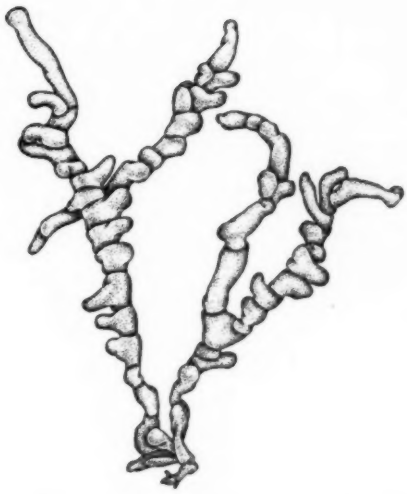

FIG. 9. *Siphonocladus rigidus:* Habit of a plant of D. 12574, × 5.

Siphonocladus rigidus Howe 1905*a*: 245, pls. 13–14 (Bahamas Islands)
Fig. 9

KWAJALEIN ATOLL: D. 12574, Sta. 1. Although this material is somewhat depauperate, it is in excellent agreement with Howe's plant which heretofore has been recorded only from the Atlantic Caribbean region.

ARNO ATOLL: H. 9333d, Sta. 24; H. 9505, Sta. 28. These are more repent in habit than either Atlantic or Kwajalein specimens seen but hardly to be distinguished otherwise.

Anadyomene wrightii Gray 1866: 48, pl. 44, fig. 5 (Ryukyu Archipelago); Dawson 1954: 390, fig. 9e

JALUIT ATOLL: D. 13105, Sta. 18. Most of these specimens from high intertidal rock clefts are dwarfish, but some are sufficiently well developed to show satisfactory comparison with Japanese and Vietnamese examples.

ARNO ATOLL: H. 9190, Sta. 24; H. 9491, Sta. 28. Small, but good, well developed material.

FIG. 10. *Rhipidiphyllon reticulatum:* Part of a plant from H. 9372b to show branching, × 12.5.

Rhipidiphyllon reticulatum (Askenasy) Heydrich 1894: 281, pl. 15, fig. 1; Taylor 1950: 47; Børgesen 1924: 251, figs. 3–4. *Anadyomene reticulata* Askenasy 1888: 5, pl. 2, fig. 7 (Dirk Harteg Isl., West Australia)

Fig. 10

ARNO ATOLL: H. 9372b, H. 9486, H. 9487a, Sta. 28; H. 9444a, Sta. 24.

Microdictyon okamurai Setchell 1929: 553, fig. 76–84 (Ryukyu Islands); Yamada 1934: 40, figs. 6–7; Taylor 1950: 46, pl. 27, fig. 1

Fig. 11*a*

KWAJALEIN ATOLL: D. 12551, Sta. 1; D. 12627, Sta. 2.

JALUIT ATOLL: D. 13101, Sta. 18.

ARNO ATOLL: H. 9592b, Sta. 25 (cell walls mostly under 7 μ); H. 9390a, Sta. 26.

The cell walls in this species are very thin, about 3–5 (6) μ thick, compared to *M. setchellianum* in which they are mostly over 10 μ thick, sometimes up to 16–20 μ. The segment and mesh diameters of the two species are similar, although some forms of *M. setchellianum* are considerably coarser. Setchell's illustrations are ample and explicit.

Microdictyon setchellianum Howe 1934: 38 (Honolulu, Hawaii); Egerod 1952: 366, pl. 33, fig. 6c–g; Setchell 1929: 561, figs. 85–92 (as *M. velleyanum*)

Fig. 11*b*

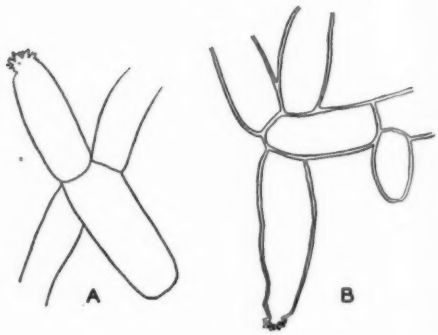

FIG. 11. *a, Microdictyon okamurai:* A few cells, one with fibula, showing the thin walls, × 38; *b, Microdictyon setchellianum:* A few cells, one with fibula, showing the thick walls, × 38.

ARNO ATOLL: H. 9372, Sta. 26; H. 9345a, Sta. 26 (cell walls mostly 7–10 μ thick); H. 9343b, Sta. 27; H. 9495, Sta. 28 (a very dark green, coarse form).

Microdictyon pseudohapteron Gepp and Gepp 1908: 165, pl. 22, figs. 1–4 (Western Indian Ocean); Setchell 1929: 549, figs. 71–75

Fig. 12

ARNO ATOLL: H. 9628a, Sta. 24. A single small tufted plant is present of this species, but is readily distinguished by its relatively delicate frond from the coarser *M. okamurai* and *M. setchellianum* of which the former grew in the same immediate locality. The filaments reach a maximum of somewhat less than 200 μ while the outer cells are only about 100 μ in diameter.

Rhizoclonium samoense Setchell 1924: 177, fig. 42 (Tutuila, Samoa)

Fig. 13*a*

JALUIT ATOLL: D. 13154, Sta. 22, at highest intertidal level under shade of trees with partial fresh-water influence. This material with filaments 45–70 μ in diameter is in close agreement with Setchell's plant which came from the same kind of habitat in Samoa and is of similar filament diameter (45–80 μ). Whether his species is really distinct from the widespread *R. tortuosum* (Dillw.) Kütz. seems, however, to be doubtful.

ARNO ATOLL: H. 9487, Sta. 28, from deep under an overhanging beach rock slab, may be the same as the above, although a more densely intertwined, pulvinate rather than fleecy mass is formed of somewhat more branched filaments.

Chaetomorpha indica Kützing 1849: 376 (Tranquebar, southeast India); Børgesen 1935: 12, fig. 2; Dawson 1954: 386, fig. 6f, g

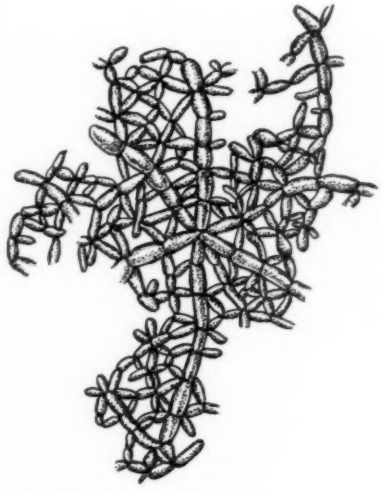

FIG. 12. *Microdictyon pseudohapteron:* Reproduction of original illustration of the Gepps' Indian Ocean type, × 8.

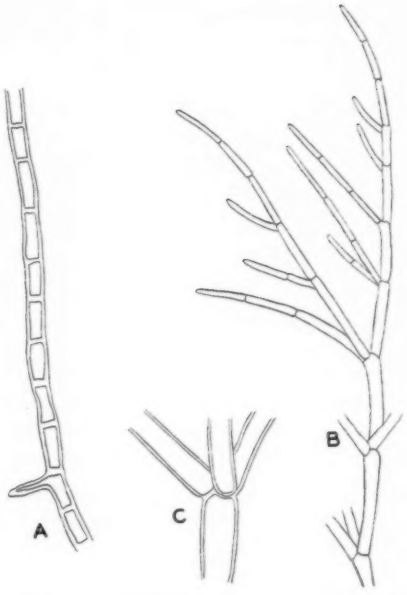

FIG. 13. *a, Rhizoclonium samoense:* A small part of a single filament from D. 13154, × 66. *b, c, Cladophora crystallina,* D. 12658: *b,* An upper part of a plant to show branching, × 50; *c,* a lower part of the same plant, × 50.

KWAJALEIN ATOLL: D. 12661, Sta. 5, in good agreement with both the Bombay and Viêt Nam plants cited above.

MAJURO ATOLL: D. 12745a, Sta. 8. This is apparently an entangled, partly free form of this species growing with *Cladophoropsis sundanensis.*

Cladophora crystallina (Roth) Kützing 1845: 213; Hamel 1929: 53, fig. 12B. *Conferva crystallina* Roth 1797: 196 (Baltic Sea)

Fig. 13*b, c*

KWAJALEIN ATOLL: D. 12658a, Sta. 5, mixed with *Enteromorpha kylinii* and *E. ralfsii.* With a diameter of about 110 μ below and ultimate branches of about 20 μ diameter, this corresponds excellently with Hamel's interpretation of this species although only about 2–3 cm. in height. The small diameter

and pectinate branching of the ultimate segments are characteristic together with the gradually enlarged lower segments.

Cladophora socialis Kützing 1849: 416; 1854, Tab. Phyc. 4: pl. 71 (Tahiti); Børgesen 1946: 28. *Cladophora patentiramea* var. *longiarticulata* Reinbold, in Weber van Bosse 1913: 84; Dawson 1954: 388, fig. 7e

JALUIT ATOLL: D. 13088, Sta. 16. The present material is much like the Kützing type in habit, but has longer cells. Børgesen's study of similar plants from Mauritius has led to his conclusion that Reinbold's Indonesian plant is only a form of *C. socialis* with longer cells.

Bryopsis indica Gepp and Gepp 1908: 169, pl. 22, figs. 10–11 (Coetivy Reef, Indian Ocean); Taylor 1950: 50

Fig. 14*a*

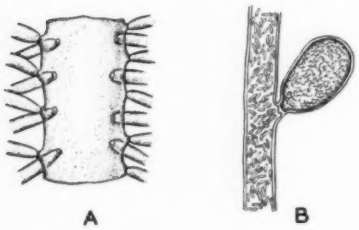

FIG. 14. *a*, *Bryopsis indica:* Reproduction of the Gepps' original illustration of a small portion of the type showing the double row of pinnae, × 37. *b*, *Derbesia ryukiuensis:* A single sporangium from H. 9520, × 187.

ARNO ATOLL: H. 9472, H. 9543, Sta. 24. These specimens agree well with this Indian Ocean species recently reported by Taylor from Eniwetok Atoll. They are symmetrically branched like the type, not secund near the tip as Taylor's. The double row of pinnae on either side is distinctive.

Bryopsis pennata Lamouroux 1809*a*: 134, pl. 3, fig. 1a, b (Antilles); Dawson 1954: 393, fig. 11b

KWAJALEIN ATOLL: D. 12602, Sta. 2 (with partly tetrastichous pinnae which are very long); D. 12667, Sta. 5.

MAJURO ATOLL: D. 12709, Sta. 6; D. 12715, lagoon shore of Enierippu Island in 2–5 ft. at low tide.

JALUIT ATOLL: D. 13052, Sta. 13; D. 13067, Sta. 15; D. 13127, Sta. 19; D.13153, Sta. 21.

ARNO ATOLL: H. 9176, H. 9219, H. 9260, Sta. 24.

Derbesia ryukyuensis Yamada and Tanaka 1938: 64, fig. 5 (Pinai, Yonakuni Island, Ryukyu Archipelago)

Fig. 14*b*

ARNO ATOLL: H. 9520, H. 9542, H. 9551, Sta. 24. This richly developed material from the reef drop-off is in very good agreement with the type as illustrated (l.c.), especially as to details of structure of the sporangia. The specimens are somewhat smaller throughout as to diameter of filaments (about 25 μ) and size of sporangia (about 80 μ long), but on the other hand some of them are much more extensively developed vegetatively, up to 7–9 cm. long and forming an entangled skein.

Derbesia marina (Lyngbye) Solier 1847: 158. *Vaucheria marina* Lyngbye 1819:79, pl. 22, fig. A (Denmark)

Fig. 15

JALUIT ATOLL: D. 13048, 13057, Sta. 13. This material is somewhat smaller than average, but is larger than the plants described as *Derbesia minima* Weber van Bosse. The shape, proportions and pedicellation of the sporangia agree well with *D. marina*.

Derbesia attenuata Dawson 1954: 390, fig. 9a, b (Nhatrang, Viêt Nam)

MAJURO ATOLL: D. 12685, Sta. 6; D. 12750, Sta. 8.

JALUIT ATOLL: D. 13146, Sta. 20; (a confusing mixture in which some of the plants seem to grade into a *Bryopsis*-like form).

ARNO ATOLL: H. 9165b, H. 9290a, Sta. 24. Material corresponding with the type has

recently been recognized at Isla Socorro, Mexico as well as at these several Marshall Island stations. It is suspected that it is not an autonomous species, but a stage in the development of some other green alga.

Caulerpa racemosa var. **macrophysa** (Kütz.) Taylor 1928: 101, pl. 12, fig. 3, pl. 13, fig. 9; Taylor 1950: 63; Dawson 1954: 393, fig. 10c. *Chauvinia macrophysa* Kützing 1857, Tab. Phyc. 7: 6, pl. 15 II (Central America)

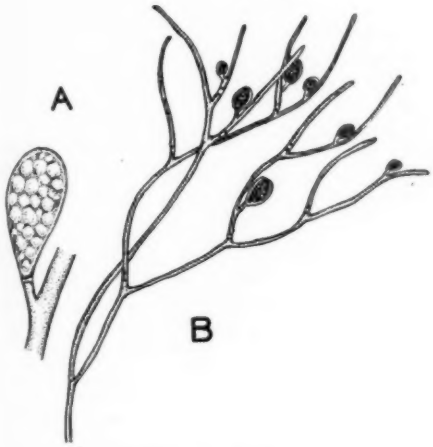

FIG. 15. *Derbesia marina: a,* Mature sporangium, × 300; *b,* habit of part of a fertile plant, × 17 (redrawn from Saunders).

JALUIT ATOLL: D. 13166, Sta. 23.
ARNO ATOLL: H. 9576b, Sta. 25.

Caulerpa racemosa var. **turbinata** (J. Ag.) Eubank 1946: 420, fig. 2o–q. *Caulerpa clavifera* var. *turbinata* J. Agardh 1837: 173 (Red Sea)

Fig. 16*a*

KWAJALEIN ATOLL: D. 12556, Sta. 1. These plants have ramuli of variable form on a single individual.

Caulerpa racemosa var. **peltata** (Lam.) Eubank 1946: 421, fig. 2r, s. *Caulerpa peltata* Lamouroux 1809*b*: 145; Taylor 1950: 65

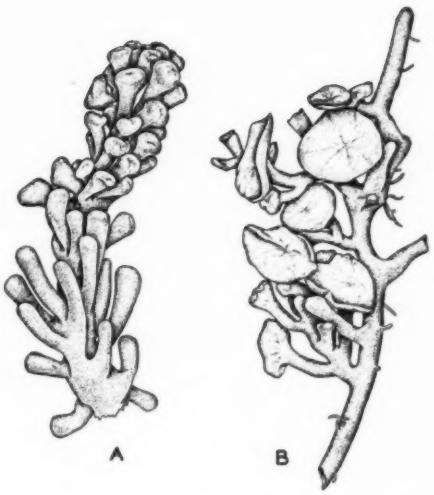

FIG. 16. *a, Caulerpa racemosa* var. *turbinata:* A small upper part of a plant of D. 12556, × 4; *b, Caulerpa racemosa* var. *peltata:* A small part of a plant of D. 13119, × 4.

Fig. 16*b*

KWAJALEIN ATOLL: D. 12562, Sta. 1; D. 12624, Sta. 2; D. 12675, Sta. 5.
MAJURO ATOLL: D. 12720, lagoon shore of Enierippu Island.
JALUIT ATOLL: D. 13029, Sta. 12; D. 13119, Sta. 19.
ARNO ATOLL: H. 9682, Sta. 25.

Caulerpa taxifolia (Vahl) C. Agardh 1822: 435; Yamada 1934: 67, figs. 36–37. *Fucus taxifolius* Vahl 1799: 36 (West Indies)

Fig. 17

ARNO ATOLL: H. 9684, Sta. 25. Rather dwarfish material but identical with Ryukyu specimens illustrated by Yamada.

Caulerpa vickersiae Børgesen 1911: 129 (Virgin Islands). Dawson 1954: 392, fig. 9f (as *C. ambigua* Okam.); Eubank 1946: 410, pl. 22, fig. 2a, b (as *C. ambigua*)

Fig. 18

FIG. 17. *Caulerpa taxifolia:* Habit of part of a plant, × 1.5 (redrawn from Yamada).

FIG. 18. *Caulerpa vickersiae:* Part of a plant of D. 12564a showing the regular distichous branching, × 9.

KWAJALEIN ATOLL: D. 12564a, Sta. 1. These specimens are in full agreement with Børgesen's West Indian plant and with specimens from Viêt Nam reported under the name *C. ambigua*. The fortunate discovery in the reef turf on Kwajalein Island of specimens which match the original figures of Okamura's *C. ambigua* and which show such clear distinction from *C. vickersiae* growing in the same habitat, has led me to the following conclusions regarding these two names which have been discussed in recent years alternately by Eubank-Egerod and by Børgesen. Børgesen was right in his interpretation that Okamura had mixed two species in preparing his initial account of *C. ambigua* Okamura (1897: 4, pl. 1, figs. 3–12) and that his description and figures applied mainly to the one of these having basally contracted branches. This plant with basally contracted, multifarious branchlets, unlike those of *C. vickersiae* Børgesen, was maintained by Okamura as representative of his species up to the time of his death (see Okamura 1936: 105, fig. 54). The figures presented here show how clearly distinct are these two plants which are sometimes found growing side by side in the same reef turf.

JALUIT ATOLL: D. 13022, Sta. 12. This small specimen is for the most part bifurcately and multifariously branched. It shows considerable superficial resemblance to *C. ambigua* and is apparently like the multifariously branched Hawaiian specimens confused by Eubank with *C. ambigua*. It is distinct from *C. ambigua* in lacking the swollen, basally contracted branchlets and in being irregularly and incompletely multifarious.

Caulerpa ambigua Okamura 1897: 4, pl. 1, figs. 3–8, 11–12 (Ryukyu Islands); Okamura 1936: 105, fig. 54

Fig. 19

KWAJALEIN ATOLL: D. 12673a, Sta. 5. See comments above under *C. vickersiae*.

Caulerpa antoensis Yamada 1944*b*: 27, pl. 1, fig. 1 (Ant Atoll, near Ponape, Caroline Islands)

Fig. 20

MAJURO ATOLL: D. 12692, Sta. 6; D. 12725, Sta. 7. This material is identical with specimens seen by the writer from Saipan and probably is the same as that which Taylor

(1950: 55, pl. 28, fig. 2) has described from Rongelap Atoll as *Caulerpa arenicola*. Some of the specimens are more irregularly branched than others.

ARNO ATOLL: H. 9681a, Sta. 25.

Caulerpa elongata Weber van Bosse 1898: 271, pl. 21, figs. 5–6 (Macassar, Indonesia); Taylor 1950: 54, pl. 28, fig. 1, pl. 52, fig. 1

ARNO ATOLL: H. 9592, H. 9599f, H. 9601, Sta. 25. This is in full agreement with the species as recently reported by Taylor from Bikini Atoll. Both distichous and polystichous branching occur on the plants of these collections.

FIG. 19. *Caulerpa ambigua:* A plant of D. 12673a showing the multifarious branching and basally contracted branchlets, × 8.

Caulerpa verticillata J. Agardh 1847: 6 (Atlantic Mexico); Taylor 1950: 54; Dawson 1954: 392, fig. 10b

MAJURO ATOLL: D. 12783, Sta. 11.

ARNO ATOLL: H. 9059b, H. 9681, H. 9685, Sta. 25.

Caulerpa urvilliana Montagne 1845: 21 (Toud Island, Torres Straits ?); Taylor 1950: 60, pl. 31, fig. 1, pl. 32, fig. 1

Fig. 21

FIG. 20. *Caulerpa antoensis:* Part of a plant from D. 12692 showing many sand grains adhering to rhizoids, × 5.

KWAJALEIN ATOLL: D. 12595, Sta. 1; D. 12656, Sta. 4.

MAJURO ATOLL: D. 12696, Sta. 6.

ARNO ATOLL: H. 9581b, Sta. 25; H. 9373a, Sta. 27; H. 9493, Sta. 28; H. 9614a, Sta. 29.

The material of these collections is vari-

FIG. 21. *Caulerpa urvilliana* var. *urvilliana* f. *tristicha:* A small upper part of a plant of D. 12656, × 3.

able, some being dwarfish and depauperate while others are vegetatively well developed. The better developed ones correspond with what Taylor calls var. *typica* f. *tristicha* (J. Ag.) Weber van Bosse.

Caulerpa sertularioides (Gmelin) Howe 1905*b*: 576. *Fucus sertularioides* Gmelin 1768: 151, pl. 15, fig. 4 ("America")
Fig. 22

FIG. 22. *Caulerpa sertularioides:* Habit of a plant from D. 12655, × 1.5.

KWAJALEIN ATOLL: D. 12655, Sta. 4.

Caulerpa serrulata (Forsk.) J. Agardh, emend. Børgesen 1932: 5, pl. 1, fig. 2; Taylor 1950: 57, pl. 29, fig. 1, pl. 30; Dawson 1954: 393, fig. 10a. *Fucus serrulatus* Forskål 1775: 179 (Red Sea)
Fig. 23

KWAJALEIN ATOLL: D. 12563, Sta. 1; D. 12680, Sta. 5.

MAJURO ATOLL: D. 12785, Sta. 11. This material corresponds with the type variety of the species which Taylor has called *C. serrulata* var. *typica* f. *serrulata* (Weber van Bosse) Gilbert.

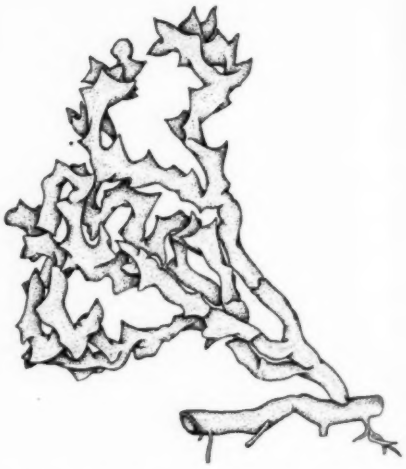

FIG. 23. *Caulerpa serrulata* var. *serrulata* f. *spiralis:* Part of a plant from H. 9225, × 3.5.

JALUIT ATOLL: D. 13064, Sta. 15; D. 13144, Sta. 21.

ARNO ATOLL: H. 9159, H. 9550, Sta. 24. These correspond with var. *boryana* (J. Ag.) Gilbert as reported and illustrated by Taylor (1950: 59, pl. 30, fig. 2). H. 9225, H. 9262, Sta. 24. These correspond with var. *typica* f. *spiralis* (Weber van Bosse) Gilbert as interpreted by Taylor in his text although the name "var. *typica* f. *angusta*" is employed in his key.

Codium arabicum Kützing[5] 1856, Tab. Phyc. 6: 35, pl. 100, fig. 2 (Tor, Sinai Peninsula, Gulf of Suez, Egypt)
Fig. 24

KWAJALEIN ATOLL: D. 12550, Sta. 1.

MAJURO ATOLL: D. 12758, Sta. 9; D. 12775, Sta. 10.

JALUIT ATOLL: D. 13081, Sta. 16.

ARNO ATOLL: H. 9599a, Sta. 25.

[5] This and all other *Codium* material cited here was determined by Dr. P. C. Silva.

Codium ovale Zanardini 1878: 37 (New Guinea)

Fig. 25

KWAJALEIN ATOLL: D. 12598, Sta. 2.
MAJURO ATOLL: D. 12778, Sta. 11.

Codium geppii O. C. Schmidt 1923: 50, fig. 33 (Malaya); Dawson 1954: 395, fig. 13k

Fig. 26

KWAJALEIN ATOLL: D. 12552, Sta. 1; D. 12606, Sta. 2. Dr. Silva, in a personal communication, says of these plants: "This material is certainly to be assigned to the *geppii* complex, but just where it fits into the picture I cannot say for the moment. It is closer to *C. edule* from Hawaii than to typical *geppii* from Indonesia; that is, the branches are thicker and less markedly divaricate than in typical *geppii*. It matches material from the Philippines and from Okinawa very nicely."
MAJURO ATOLL: D. 12733, Sta. 7; D. 12744, Sta. 8.
JALUIT ATOLL: D. 13002, Sta. 12.

Pseudochlorodesmis furcellata (Zarnard.) Børgesen 1925: 78, figs. 30–34; Dawson 1954: 395, fig. 11c. *Bryopsis furcellata* Zanardini 1843: 60 (Adriatic Sea)

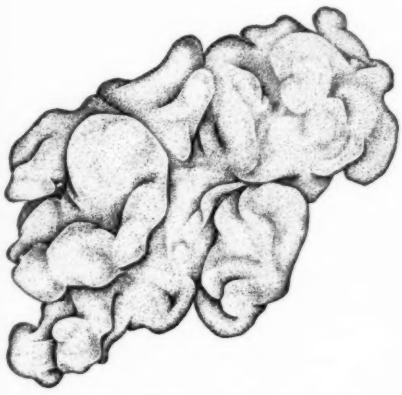

FIG. 24. *Codium arabicum:* Habit of a plant from D. 12758, × 1.5.

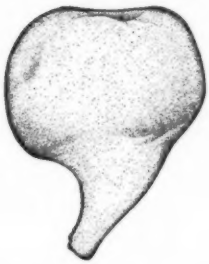

FIG. 25. *Codium ovale:* Habit of a plant from D. 12778, × 2.

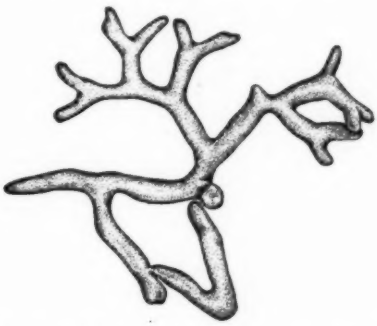

FIG. 26. *Codium geppii:* Habit of part of a plant from D. 12606, × 1.

KWAJALEIN ATOLL: D. 12570a, Sta. 1.

Geppella mortensenii Børgesen 1940: 55, figs. 16–18 (Mauritius)

Fig. 27

ARNO ATOLL: H. 9462, Sta. 24; H. 9581g, Sta. 25. Several small plants are present in these collections of mixed small algae. They are somewhat less broadly flabellately developed than Børgesen's type, but otherwise are identical in size and structure with this species known heretofore only from Mauritius.

Avrainvillea nigricans Decaisne 1842: 108 (near Guadeloupe, West Indies); Taylor 1950: 69, pl. 34, fig. 2

ARNO ATOLL: H. 9576a, Sta. 25. Two poor, somewhat fragmentary specimens are in agreement with Taylor's material from Rongerik

FIG. 27. *Geppella mortensenii:* Habit of a plant from H. 9462, × 10.

and Bikini atolls and assigned to this West Indian species with some doubt. In view of the occurrence of a number of other tropical species both in the Marshall Islands and the West Indies, this distribution does not seem extraordinary. In any case, the characters of the present materials do not suggest a distinction from this species as elaborately treated by A. and Ethel Gepp (1911).

Rhipilia orientalis A. and Ethel Gepp 1911: 57, figs. 134–136 (Borneo Bank); Taylor 1950: 72, pl. 36, fig. 1

ARNO ATOLL: H. 9185, H. 9167, Sta. 24. These fine specimens from the reef drop-off are in excellent agreement with those of the original account, even as to the thin, "translucent" character of some of the thalli. The thallus filaments are more slender in general, ranging from 18–30 μ, but the variation between and within specimens would suggest that this is an environmental response. Like Taylor's northern Marshall Island specimens, the tenacula vary from two-to four-pronged. Yamada (1944*a*) has described a species, *Rhipilia micronesica*, from Ant Atoll, Caroline Islands, basing its distinction from *R. orientalis* on more slender frond filaments (20–32 μ) and the tentacular processes occurring only in pairs. The variability of the present specimens in these respects suggests that Yamada's plants are probably essentially the same as some of ours and doubtfully distinct from *R. orientalis*. Examination of more material from the type locality will be necessary to settle this point.

Horwitz 9360, Sta. 25, seems to represent a large, heavier, greener form of *R. orientalis*. Although taken on the reef flat in full light, the plants are of size and color suggesting *R. diaphana* Taylor, a deep-water plant. The structure so corresponds with *R. orientalis* as to preclude assignment to one of the other species such as *R. tomentosa* or *R. tenaculosa*.

Udotea palmetta Decaisne 1842: 380, pl. 17, fig. 15 (Galega Island, Western Indian Ocean ?); A. and Ethel Gepp 1911: 122, figs. 10, 11, 54; Børgesen 1940: 59
Fig. 28

KWAJALEIN ATOLL: D. 12554, Sta. 1.
MAJURO ATOLL: D. 12743, Sta. 8.
ARNO ATOLL: H. 9576, H. 9599c, Sta. 25; H. 9340a, H. 9390e, Sta. 26.

Most of the specimens are much smaller than the type illustrated by the Gepps, but among the Arno collections are some specimens under H. 9576.which are almost identical in size with the type and also in satisfactory agreement on anatomical details.

From Taylor's (1950) discussion and illustrations of plants attributed to *U. indica* one gets the impression that they should instead be referred to *U. palmetta*, for he says "but the blade filament appendages are often much longer and less blunt [than in *U. indica* figured by the Gepps], never truncate."

Udotea javensis (Mont.) A. and Ethel Gepp 1904: 363; Taylor 1950: 73; Dawson 1954: 395, fig. 13 b, c. *Rhipidosiphon javensis* Montagne 1842: 15 (Java)

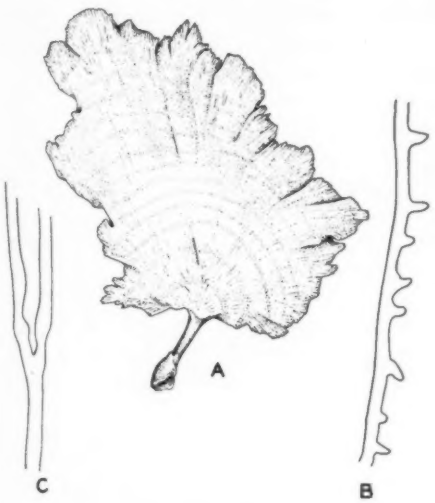

FIG. 28. *Udotea palmetta: a*, Habit of a relatively large plant from H. 9576, × 1; *b*, exposed part of a thallus filament showing the lateral appendages, × 114; *c*, part of an inner thallus filament showing a dichotomy, × 114.

MAJURO ATOLL: D. 12716, lagoon side of Enierippu Isl.; D. 12779, Sta. 11.

JALUIT ATOLL: D. 13046, Sta. 13.

Tydemannia expeditionis Weber van Bosse 1901:139 (Indonesia); Taylor 1950: 73, pl. 38, fig. 1; Srinivasan 1954: 247–255

JALUIT ATOLL: D. 13060, Sta. 13; D. 13123, D. 13128, Sta. 19 (includes a plant showing the flabellate form of the thallus); D. 13163, Sta. 23.

Halimeda fragilis Taylor 1950: 88, pl. 48, fig. 2 (Eniwetok Atoll, Marshall Islands)

ARNO ATOLL: H. 9160, Sta. 24; H. 9673, Sta. 25. These specimens from reef drop-offs are in full agreement with Taylor's account.

Halimeda monile (Solander) Lamouroux 1812: 186; Taylor 1950: 92, pl. 50, fig. 1. *Halimeda incrassata* f. *monilis* (Solander) Barton 1901: 27, pl. 4, fig. 40: Yamada 1941: 118, fig. 12. *Corallina monile* Solander 1786: 110, pl. 20, fig. c (Jamaica)

KWAJALEIN ATOLL: D. 12653, Sta. 4; D. 12670, Sta. 5.

MAJURO ATOLL: D. 12755, Sta. 8. This appears to be a short, much-branched, depauperate form of this plant resembling the Indonesian specimens illustrated by Barton (1901: pl. 4, fig. 44) as *H. incrassata* f. *pusilla*.

Halimeda cuneata f. **digitata** Barton 1901: 16, pl. 2, fig. 9 (Indonesia); Yamada 1941: 111, fig. 4.

Fig. 29

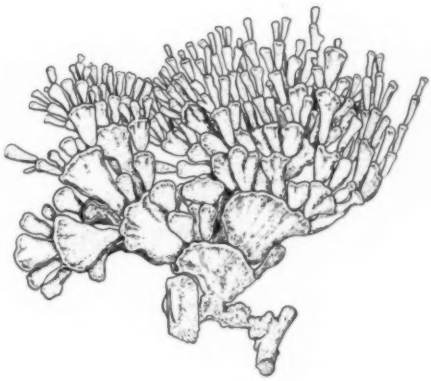

FIG. 29. *Halimeda cuneata* f. *digitata:* Habit of a plant, × 0.55 (redrawn from Yamada).

KWAJALEIN ATOLL: D. 12620, Sta. 2. Identical with the illustration of the type.

Halimeda stuposa Taylor 1950: 90, pl. 43, fig. 1, pl. 49, pl. 50, fig. 2 (Naen Island, Rongelap Atoll, Marshall Islands)

KWAJALEIN ATOLL: D. 12621, Sta. 2.

Halimeda opuntia (L.) Lamouroux 1816: 308; Taylor 1950: 80, pl. 39, fig. 1; Dawson 1954: 395, fig. 12. *Corallina opuntia* Linnaeus 1758: 805, in part (Mediterranean Sea)

KWAJALEIN ATOLL: D. 12619, Sta. 2.

JALUIT ATOLL: D. 13099, Sta. 13. An abundant form making large clumps in depths of 5 meters or more, but with quite delicate segments. D. 13112, Sta. 18. A coarser, distinctly ribbed form near what Taylor calls f. *hederacea*. D. 13124, Sta. 19. A form somewhat intermediate between f. *hederacea* and f. *minima*.

Halimeda gracilis Harvey, ex. J. G. Agardh 1887: 82 (Ceylon); Taylor 1950: 83, pl. 42

ARNO ATOLL: H. 9525x, H. 9545, Sta. 24. These specimens from the reef drop-off at depths of about 6 meters seem to be nearly identical with the forma *elegans* Yamada (1944*b*: 28, pl. 3) described from Palao, Caroline Islands. In 1941, previous to the 1944 validation with Latin, he gave a better figure, number 11 on page 117, together with a Japanese diagnosis.

Halimeda taenicola Taylor 1950: 86, pl. 46, fig. 1 (Rongerik Atoll, Marshall Islands)

JALUIT ATOLL: D. 13111, Sta. 18.

Neomeris mucosa Howe 1909: 84, pl. 1, fig. 5, pl. 5, figs. 1–14 (Bahamas Islands); Yamada and Tanaka 1938: 59, fig. 3

Fig. 30*c*

ARNO ATOLL: H. 9474, Sta. 28. This single clump of nine axes is in good habit agreement with Howe's photograph of the liquid-preserved type and with Yamada and Tanaka's fine illustration of a far western Pacific specimen. The sporangia are like that figured by Koster (1937) and reproduced here. The excessively mucous character of the plants together with the distinctive difference in the peduncle of the sporangia set this species apart from the closely related *N. bilimbata*. The plant is found in the Bahamas growing together with *Neomeris annulata*, as it also is in the Ryukyu Archipelago.

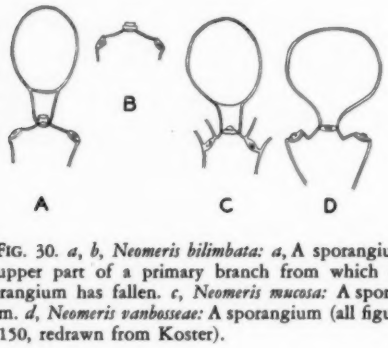

FIG. 30. *a*, *b*, *Neomeris bilimbata: a*, A sporangium; *b*, upper part of a primary branch from which the sporangium has fallen. *c*, *Neomeris mucosa:* A sporangium. *d*, *Neomeris vanbosseae:* A sporangium (all figures × 150, redrawn from Koster).

Neomeris bilimbata Koster 1937: 221, pl. 15, figs. 1, 4, 5 (Itu-Aba, South China Sea)

Fig. 30*a*, *b*

KWAJALEIN ATOLL: D. 12549, Sta. 1. This material, with which a few examples of *Neomeris annulata* are mixed, agrees in detail with the plant described by Koster. The distinctive differences between the sporangia of this species and of *N. vanbosseae* and *N. mucosa* are shown in her illustrations reproduced here. It would seem that the plants attributed by Taylor (1950) to *N. vanbosseae* may be of this species. He says they "were rather smaller in stature than those described by Howe and likewise differed slightly in many structural details."

JALUIT ATOLL: D. 13100, Sta. 18.

Neomeris annulata Dickie 1874: 198 (Mauritius); Egerod 1952: 400, pl. 40, text fig. 21a–l, 22a, c; Dawson 1954: 396, fig. 13e

KWAJALEIN ATOLL: D. 12549a, Sta. 1; D. 12679, Sta. 5.

MAJURO ATOLL: D. 12780, Sta. 11.

Acetabularia exigua Solms-Laubach 1895: 28, pl. 2, figs. 1, 4 ("Tropical eastern Asia, Macassar, Celebes")

Fig. 31

KWAJALEIN ATOLL: D. 12644, Sta. 2. This material is rather variable in ray number and shape, but is in satisfactory agreement with this species.

FIG. 31. *Acetabularia exigua:* Habit of a plant of D. 12644, × 10.

ARNO ATOLL: H. 9238a, Sta. 24. A few individuals growing with more numerous *A. moebii*.

Acetabularia moebii Solms-Laubach 1895: 30, pl., 4, fig. 1 (Mauritius); Dawson 1954: 397, fig. 13j

KWAJALEIN ATOLL: D. 12642, Sta. 2.
MAJURO ATOLL: A single individual examined but no specimen made.
JALUIT ATOLL: D. 13008, Sta. 12.
ARNO ATOLL: H. 9232, H. 9238, Sta. 24.

Ectocarpus indicus Sonder, in Zollinger 1854: 3 (Indonesia); Weber van Bosse 1913: 129, fig. 34; Børgesen 1941: 16, figs. 6–7; Taylor 1950: 95; 6–7. *E. duchassaignianus* Grunow 1867: 45, pl. 4, figs. a, b, c
Fig. 32

KWAJALEIN ATOLL: D. 12630, D. 12637, Sta. 2. This material is fertile and well developed. The irregular branching seems to be a criterion for distinguishing this plant from *E. mitchellae* in which the plurilocular sporangia are often similar. Vickers and Shaw's (1908) illustration of *E. duchassaignianus* (= *E. indicus*) shows this branching distinction well when compared with their figure of *E. guadeloupensis* (= *E. mitchellae*).

Ectocarpus breviarticulatus J. Agardh 1847: 7 (Pacific southern Mexico); Dawson 1954: 398, fig. 14, a, b

MAJURO ATOLL: D. 12773, Sta. 10.
JALUIT ATOLL: D. 13089, Sta. 16.

Ectocarpus mitchellae Harvey 1852: 142, pl. 12G (Massachusetts, U. S. A.); Taylor 1950: 95; Dawson 1954: 400, fig. 14 c, d

MAJURO ATOLL: D. 12741, Sta. 7. Note the difference in branching from *E. indicus* as mentioned above.

Ralfsia expansa J. Agardh 1847: 7 (Vera Cruz, Mexico); Børgesen 1914: 189, figs. 146–148; Weber van Bosse 1913: 146, fig. 45
Fig. 33

KWAJALEIN ATOLL: D. 12681, Sta. 5. Although sterile, this material agrees structurally with the figures and descriptions cited above. The bilateral condition is prominent when specimens are cut in certain planes. The identification is tentative.

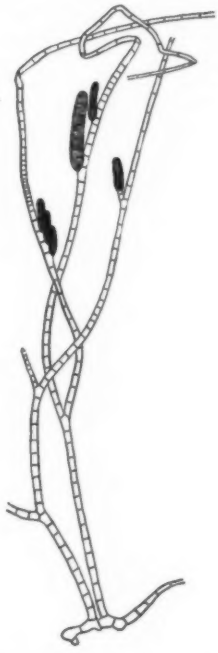

FIG. 32. *Ectocarpus indicus:* Habit of part of plant of Sonder's type collection, × 24 (redrawn from Weber van Bosse).

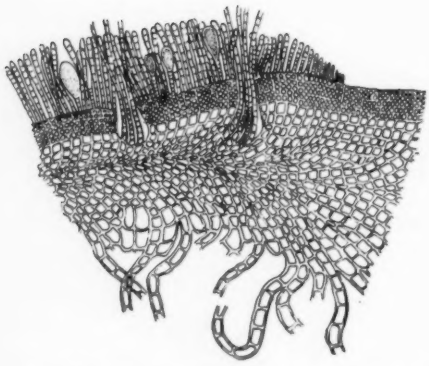

FIG. 33. *Ralfsia expansa:* Part of a transection of a fertile thallus, × 58 (redrawn from Weber van Bosse).

Sphacelaria tribuloides Meneghini 1840: 2, No. 6 (Dalmatia); Dawson 1954: 400, fig. 14i, j

KWAJALEIN ATOLL: D. 12577, D. 12588, Sta. 1; D. 12643, Sta. 3.

Sphacelaria furcigera Kützing 1855, Tab. Phyc. 5, pl. 90, fig. 2 (Karak Island, Persian Gulf); Dawson 1954: 400, fig. 14h

KWAJALEIN ATOLL: D. 12554a, Sta. 1, epiphytic on *Udotea*.

JALUIT ATOLL: D. 13044b, Sta. 13; D. 13172b, Sta. 23.

Pocockiella variegata (Lamx.) Papenfuss 1943: 467, figs. 1–14; Taylor 1950: 97; Dawson 1954: 400, fig. 14k. *Dictyota variegata* Lamouroux 1809*c*: 331 (Antilles)

JALUIT ATOLL: D. 13000, Sta. 12.

ARNO ATOLL: H. 9281a, Sta. 24; H. 9340b, Sta. 26; H. 9367, Sta. 25.

Pocockiella papenfussii Taylor 1950: 98, pl. 54, fig. 2 (Bikini Atoll, Marshall Islands)

ARNO ATOLL: H. 9267, H. 9284, Sta. 24. These include well-developed plants to 350 μ thick or more.

Padina commersonii Bory 1828: 114 (Ile de France); Taylor 1950: 100, pl. 54, fig. 1; Dawson 1954: 401, fig. 17

KWAJALEIN ATOLL: D. 12555, Sta. 1, young plants just out of the *Vaughaniella* stage.

MAJURO ATOLL: D. 12713, lagoon shore, Dalap Island; D. 12792, Sta. 11.

JALUIT ATOLL: D. 13033, sandy bottom of small boat landing at Jabor.

Dictyopteris repens (Okamura) Børgesen 1924: 265, fig. 13. *Haliseris repens* Okamura 1916: 8, pl. 1, figs. 7–18 (Truk, Caroline Islands)

Fig. 34

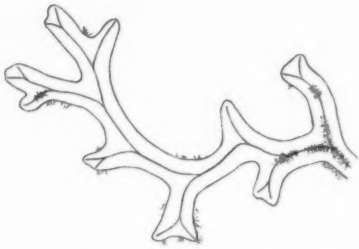

FIG. 34. *Dictyopteris repens:* Part of a plant of D. 13036 as seen from the under side showing rhizoids along the midrib and the margins, × 2.25.

JALUIT ATOLL: D. 13036, Sta. 13; D. 13147, Sta. 20.

ARNO ATOLL: H. 9260a, H. 9265, Sta. 24; H. 9581d, H. 9592c, Sta. 25.

Turbinaria trialata (J. Agardh) Kützing 1860, Tab. Phyc. 10: pl. 67, fig. 2; Yendo 1907: 43. *Turbinaria vulgaris* var. *trialata* J. Agardh 1848: 268 (tropical western Atlantic).

JALUIT ATOLL: D. 13062, Sta. 14.

Turbinaria ornata (Turn.) J. Agardh 1848: 266; Taylor 1950: 101, pl. 54, fig. 2, pl. 55, fig. 2; Dawson 1954: 405, fig. 21. *Fucus turbinatus* var. *ornatus* Turner 1808: 50, pl. 24, figs. c, d (type locality unknown)

KWAJALEIN ATOLL: D. 12654, Sta. 4.

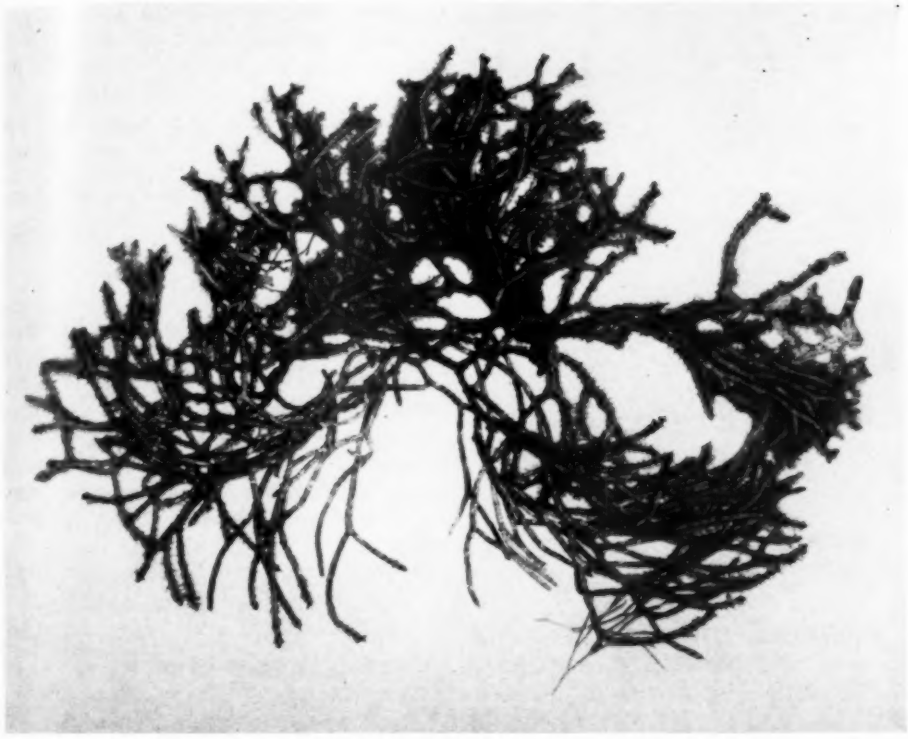

FIG. 35. *Galaxaura fasciculata:* Habit photo of a plant of D. 13098, × 1.

JALUIT ATOLL: D. 13125, Sta. 19.
ARNO ATOLL: H. 9470, Sta. 24.

Erythrotrichia carnea (Dillwyn) J. Agardh 1883: 15; Tanaka 1952: 14, fig. 7B–E; Taylor 1950: 117. *Conferva carnea* Dillwyn 1805: 54, pl. 84 (Wales)

KWAJALEIN ATOLL: D. 12558b, Sta. 1. These represent a quite slender form best referred to Tanaka's f. *tenuis*.
JALUIT ATOLL: D. 13073, Sta. 15.
ARNO ATOLL: H. 9205, H. 9534c, Sta. 24.

Falkenbergia hillebrandii (Bornet) Falkenberg = sporophyte generation of *Asparagopsis taxiformis* (Delile) Collins and Hervey; Feldmann and Feldmann 1942: 89; Dawson 1954: 414, fig. 25l. *Polysiphonia hillebrandii* Bornet, in Ardissone 1883: 376 (Italy)

KWAJALEIN ATOLL: D. 12564, D. 12591, Sta. 1.
JALUIT ATOLL: D. 13084, Sta. 16 (a rather coarse form).
ARNO ATOLL: H. 9358, H. 9598, Sta. 25.

Galaxaura fasciculata Kjellman 1900: 53, pl. 5, figs. 1–9, pl. 20, fig. 14 (Celebes Islands). Chou 1945: 44, pl. 2, fig. 2, pl. 8, fig. 1

Fig. 35

JALUIT ATOLL: D. 13098, Sta. 15.

Galaxaura acuminata Kjellman, in Butters 1911: 180 (Hawaii); Svedelius 1953: 63,

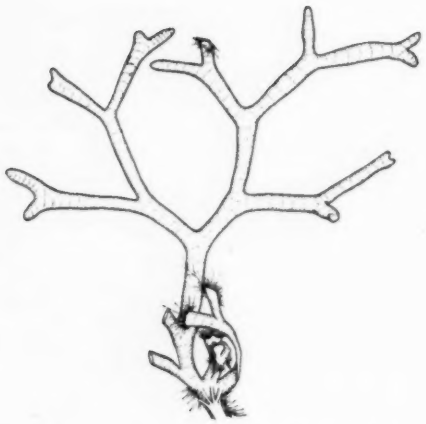

FIG. 36. *Galaxaura acuminata:* Habit of a small part of a plant of D. 13092, 1.5.

figs. 53–55, 57–60. Chou 1945: 51, pl. 5, figs. 13–19, pl. 9, fig. 1 (as *G. apiculata*) Fig. 36

JALUIT ATOLL: D. 13092, Sta. 17. This abundant material is in complete agreement with Svedelius' interpretation of this plant.

Galaxaura filamentosa Chou 1945: 39, pl. 1, figs. 1–6, pl. 6, fig. 1 (Revillagigedo Archipelago, Mexico); Dawson 1954: 419, fig. 30a

KWAJALEIN ATOLL: D. 12600, Sta. 2.
JALUIT ATOLL: D. 13082, Sta. 16; D. 13131, Sta. 19.
ARNO ATOLL: H. 9273, Sta. 24, a single small plant.

Actinotrichia fragilis (Forsk.) Børgesen 1932: 6, pl. 1, fig. 4; Dawson 1954: 416, fig. 28b. *Fucus fragilis* Forskål 1775: 190 (Red Sea)

JALUIT ATOLL: D. 13039, Sta. 13 (abundant at 5 meters and below); D. 13095, Sta. 17.

Gelidium pusillum (Stackh.) Le Jolis 1864: 139; Dawson 1954: 420, fig. 31a–c. *Fucus pusillus* Stackhouse 1801: 17, pl. 6 (England)

KWAJALEIN ATOLL: D. 12576, Sta. 1.
JALUIT ATOLL: D. 13038a, D. 13055 (creeping on *Amphiroa*), Sta. 13; D. 13078, Sta. 15.
ARNO ATOLL: H. 9224, H. 9230, Sta. 24.
Several different forms are present of which some may be referred to var. *conchicola* Piccone and Grunow and others to var. *minusculum* Weber van Bosse.

Gelidiella adnata Dawson 1954: 422, fig. 33f (Nhatrang, Viêt Nam)

ARNO ATOLL: H. 9213, H. 9246, H. 9467a, Sta. 24. These materials are apparently sterile but vegetatively are in agreement with the type and also with similar sterile specimens from Isla San Benedicto, Mexico. The determination is tentative awaiting comparison of reproduction with such similar small species as *G. stichidiospora* Dawson.

Gelidiella tenuissima Feldmann and Hamel 1936: 102 (Mediterranean France); Dawson 1954: 422, fig. 33e

MAJURO ATOLL: D. 12706, Sta. 6.
JALUIT ATOLL: D. 13153b, Sta. 21.
ARNO ATOLL: H. 9634b, H. 9640, Sta. 24.

Gelidiopsis intricata (Ag.) Vickers 1905: 61; Dawson 1954: 423, fig. 34a–d. *Sphaerococcus intricatus* C. Agardh 1822: 333 (Ravak Island)

MAJURO ATOLL: D. 12686, Sta. 6; D. 12793, Sta. 11.
JALUIT ATOLL: D. 13035 (sterile), D. 13040a (♂), Sta. 13.
ARNO ATOLL: H. 9634, Sta. 24, probably this, but very dwarfish.

Gelidopsis repens (Kützing) Schmitz 1895: 148; Weber van Bosse 1928: 425; Okamura 1931: 113. *Gelidium repens* Kützing 1868, Tab. Phyc. 18: 21, pl. 60a, b (New Caledonia)

Fig. 37

ARNO ATOLL: H. 9628, Sta. 24; H. 9346, Sta. 26.

FIG. 37. *Gelidiopsis repens:* Habit of part of a plant of H. 9628 with attached sand grains, × 2.

Wurdemannia miniata (Lmk. and DC) Feldmann and Hamel 1934: 544, figs. 9–11; Dawson 1954: 424, fig. 35. *Fucus miniatus* Lamarck and De Candolle 1815: 6 (Mediterranean France)

KWAJALEIN ATOLL: D. 12578, Sta. 1.
MAJURO ATOLL: D. 12749a, Sta. 8.
JALUIT ATOLL: D. 13172e, Sta. 23.
ARNO ATOLL: H. 9375, Sta. 27 (typical material about 140 μ in diameter).

Hildenbrandia prototypus Nardo 1834: 675 (Adriatic Sea); Dawson 1954: 424, fig. 36a, b

JALUIT ATOLL: D. 13158, Sta. 22 (growing on broken glass).

Peyssonelia conchicola Piccone and Grunow, in Piccone 1884*b*: 317, pl. 7, figs. 5–8 (Massaua, Red Sea), Dawson 1953: 105, pl. 11, figs. 12–13
Fig. 38

KWAJALEIN ATOLL: D. 12682, Sta. 5. This material is in excellent correspondence with Dawson's interpretation of Mexican specimens.

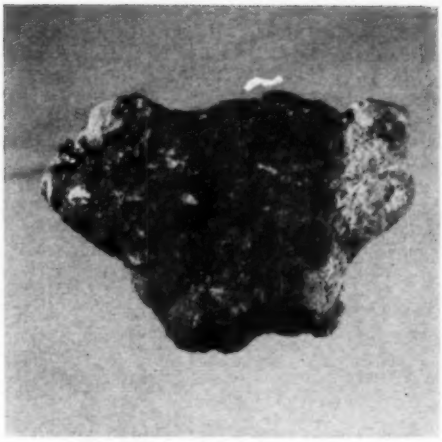

FIG. 38. *Peyssonelia conchicola:* Habit of a plant of D. 12682 growing on a coral rock fragment, × 1.

JALUIT ATOLL: D. 13080, Sta. 15; D. 13091, Sta. 17.

Peyssonelia rubra var. **orientalis** Weber van Bosse 1921: 270, figs. 86–89 (Indonesia); Taylor 1950: 121; Dawson 1953: 104, pl. 10, figs. 8, 9; Dawson 1954: 424, fig. 36c

KWAJALEIN ATOLL: D. 12614, D. 12622, Sta. 2; D. 12668, Sta. 3.
JALUIT ATOLL: D. 13006, Sta. 12; D. 13079, Sta. 15.
ARNO ATOLL: H. 9440, Sta. 24.

Cruoriella dubyi (Crouan and Crouan) Schmitz 1889: 20; Dawson 1953: 111, pl. 7, figs. 2–3. *Peyssonelia dubyi* Crouan and Crouan 1844: 367, pl. 11, figs. 6–10 (Atlantic France)
Fig. 39

KWAJALEIN ATOLL: D. 12584, D. 12585a, Sta. 1; D. 12682a, Sta. 5.

Heteroderma minutula Foslie 1904: 8 (southern Norway); Suneson 1943: 27, figs. 14, 15
Fig. 40

FIG. 39. *Cruoriella dubyi:* Habit of a well-developed thallus growing on a shell, showing the characteristic anastomosing ridges on the dry upper surface, × 6.5.

KWAJALEIN ATOLL: D. 12557a, Sta. 1, on the surface of *Dictyosphaeria intermedia* var. *solida*. This material agrees well in size, the presence of cortical (cap) cells, size of conceptacles, etc., with this species which, unlike similar *H. lejolisii*, commonly occurs as an epiphyte on algae. In some of the thalli the organization of the cell rows is rather loose, approaching the condition in f. *lacunosa* Foslie. The conceptacles are similar in size to those of *H. subtilissima*, being less than 100 μ in diameter. The distribution of this small plant is little known, and although it may be nearly cosmopolitan, has not heretofore been recorded in the Pacific.

ARNO ATOLL: H. 9390x, Sta. 24, growing on *Siphonocladus rigidus*, is very much like f. *lacunosa* as illustrated by Suneson except that the primary cell rows are composed of cells mostly twice as long as wide or more. Reproduction was not seen, but the absence of heterocysts and the presence of the cap cells points to relationship here.

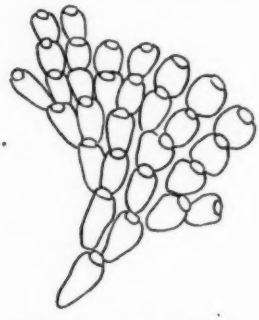

FIG. 40. *Heteroderma minutula:* A small part of a vegetative thallus (D. 12557a) showing the small cap cells and the absence of heterocysts, × 600.

Heteroderma subtilissima (Foslie) Foslie 1909: 56. *Melobesia subtilissima* Foslie, in Weber van Bosse and Foslie 1904: 55 (New Guinea)

Fig. 41

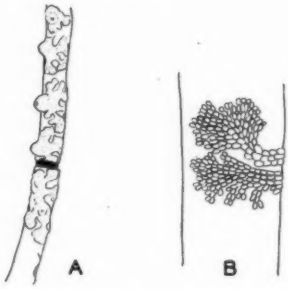

FIG. 41. *Heteroderma subtilissima: a*, Habit of fertile plants on a piece of *Jania* (D. 12558a), × 25; *b*, detail of the same showing arrangement of cells and absence of cap cells and heterocysts, × 85.

KWAJALEIN ATOLL: D. 12558a, Sta. 1, epiphytic on *Jania decussato-dichotoma*. These plants are exceedingly small and inconspicuous. Conceptacles are quite frequent, however, and aid in their recognition. Most of the conceptacles are somewhat larger than the 60 μ indicated by Foslie for the type, usually

ranging from 60 to 90 μ in outside diameter at the base, occasionally to 100 μ. No heterocysts are present nor are any cortical (cap) cells apparent in the material examined. This is in agreement with Foslie's original account of the species and marks a distinction from *H. minutula* in which the cortical cells are abundant.

Fosliella farinosa (Lamx.) Howe 1920: 587; Dawson 1954: 425, fig. 37c. *Melobesia farinosa* Lamouroux 1816: 315, pl. 12, fig. 3 (Europe)

JALUIT ATOLL: D. 13102, Sta. 18, on *Microdictyon*. Heterocysts are abundant and conspicuous, but inasmuch as conceptacles were not found for measurement, the distinction from closely related *F. paschalis* (Lemoine) Setch. and Gard. cannot be made here.

ARNO ATOLL: H. 9581e, Sta. 25, sterile plants on *Laurencia*.

Lithoporella pacifica (Heydr.) Foslie 1909: 59; Dawson 1954: 428, fig. 40b. *Melobesia pacifica* Heydrich 1901: 529 (Hawaii)

JALUIT ATOLL: D. 13058, Sta. 13; D. 13118, Sta. 19.

Jania micrarthrodia Lamouroux 1816: 271, pl. 9, fig. 5a, b (Australia). Taylor 1950: 134 (as *J. antennina* Kütz. prox.)

Fig. 42

ARNO ATOLL: H. 9371a, Sta. 24; H. 9390c, Sta. 26. These specimens are apparently like those Taylor reported from Eniwetok as *Jania antennina*. Womersley (1950) has recently reiterated the synonymy of *J. micrarthrodia* which includes both *J. antennina* Kütz. and *J. tenuissima* Sonder. In the Australian region the species seems generally to be epiphytic on large fleshy algae. The present specimens grew on branched lithothamnioids on the seaward reef ridge.

Jania capillacea Harvey 1853: 84 (Bahia Honda, Florida); Dawson 1954: 432, fig. 41a, b; Dawson 1953: 116, pl. 9, fig. 1; Taylor 1950: 133

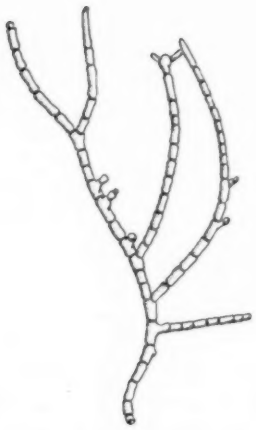

FIG. 42. *Jania micrarthrodia:* Branching and segmentation of part of H. 9371a, × 6.

KWAJALEIN ATOLL: D. 12559a, Sta. 1 (in part consisting of exceedingly slender plants ranging between 38 and 70 μ in diameter); D. 12604a, D. 12639, Sta. 2.

MAJURO ATOLL: D. 12776, Sta. 10.

JALUIT ATOLL: D. 13147a, Sta. 20; D. 13150a, Sta. 21.

ARNO ATOLL: H. 9203, H. 9274, Sta. 24.

Jania tenella Kützing 1858, Tab. Phyc. 8: 41, pl. 85, fig. 2; Dawson 1953: 120, pl. 9, fig. 3

Fig. 43

KWAJALEIN ATOLL: D. 12673, Sta. 5.

JALUIT ATOLL: D. 13013, Sta. 12; D. 13148, Sta. 14 (characteristic material with conceptacles).

Jania decussato-dichotoma (Yendo) 1905: 37. *Corallina decussato-dichotoma* Yendo 1902: 25, pl. 3, figs. 1–3, pl. 7, figs. 3–4 (southern Japan)

Fig. 44

KWAJALEIN ATOLL: D. 12558, Sta. 1. The segments are mostly 100 to 150 μ in diameter and are usually well distinguished in the algal turf from the much more slender *J. capillacea*

FIG. 43. *Jania tenella:* An isotype fragment from the Kützing collection in the Rijksherbarium, Leiden, × 18.

with which it often grows. Undoubtedly some of the plants attributed by Taylor (1950) to *Jania rubens* are referable here.

MAJURO ATOLL: D. 12697, Sta. 6. A very slender form 85 to 115 μ in diameter.

Amphiroa taylorii Dawson (prox.) 1953: 138, pl. 26, fig. 1 (Pacific Mexico)

MAJURO ATOLL: D. 12770, Sta. 10. This is a slender, sterile form with dizonal genicula. It is much like the type, but a little smaller and more branched. The branches are less crooked than in the type. Constrictions at the genicula are apparent only in dry material; the genicula are about the same diameter as the intergenicula when fresh. This plant is possibly distinct, but too close to *A. taylorii* to justify segregation on the basis of this single collection.

Amphiroa fragilissima (L.) Lamouroux 1816: 298; Dawson 1954: 430, fig. 40g, h. *Corallina fragilissima* Linnaeus 1767: 1305 (Carribbean Sea)

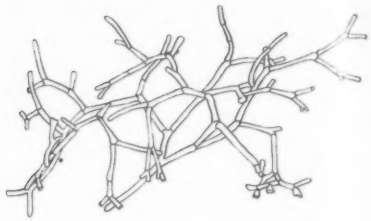

FIG. 44. *Jania decussato-dichotoma:* Part of a plant extracted from a dense clump (D. 12558) to show the decussate branching habit, × 5.

JALUIT ATOLL: D. 13043, D. 13051, Sta. 13; D. 13145, Sta. 20. These plants are for the most part representative of a variant of *A. fragilissima* near f. *cyathifera* (Lamk.) Weber van Bosse.

ARNO ATOLL: H. 9677, Sta. 25. Fertile and rather small from about 5 meters depth.

Amphiroa anastomosans Weber van Bosse, in Weber van Bosse and Foslie 1904: 91, pl. 14, figs. 3–4 (Borneo Bank, Indonesia)
Fig. 45

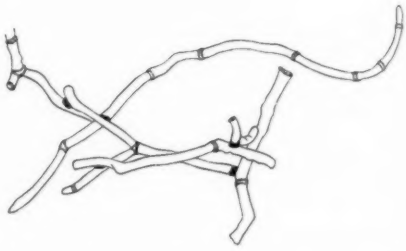

FIG. 45. *Amphiroa anastomosans:* A small part of a clump (H. 9527) showing frequent attachment of branches to each other by adherent discs, × 6.

ARNO ATOLL: H. 9527, Sta. 24. This material is somewhat larger and more laxly branched than the type illustrated by Weber van Bosse, but agrees closely in shape, proportions, dichotomous branching of the slightly contorted axes, and especially in the frequent anastomoses throughout the clumps. H. 9592e, Sta. 25.

Amphiroa foliacea Lamouroux 1824: 628, pl. 93, figs. 2–3 (Mariannas Islands); Dawson 1954: 430, fig. 40c

JALUIT ATOLL: D. 13038, Sta. 13. This material represents an exceptionally narrow form which agrees best with the East Indian forma *erecta* described by Weber van Bosse in 1904.

Hypnea pannosa J. Agardh 1847: 14 (Pacific Mexico); Tanaka 1941: 247, fig. 20; Taylor 1945: 277, pl. 71, fig. 2
Fig. 46

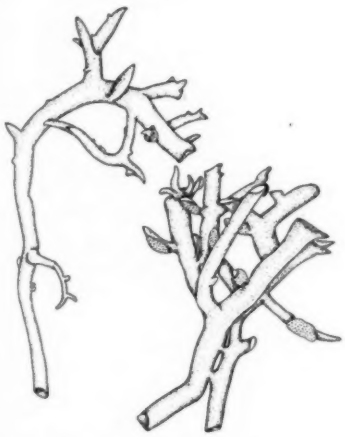

FIG. 46. *Hypnea pannosa:* Portions of two plants of D. 12734 showing tetrasporangial sori, × 5.

MAJURO ATOLL: D. 12734, Sta. 7.

JALUIT ATOLL: D. 13005, Sta. 12; D. 13090, Sta. 16.

ARNO ATOLL: H. 9266, H. 9273a, Sta. 24.

The specimens cited above are all smaller in dimensions than the coarser *H. nidulans*, but often have similar saddle-shaped nemathecia when the tetrasporangia are sharply confined to one side of a branch. Most of them are in good agreement with the type which has been seen.

Hypnea esperi Bory 1829: 157 (type locality uncertain); Dawson 1954: 436, fig. 46h–j

KWAJALEIN ATOLL: D. 12611, Sta. 2; D. 12664, Sta. 5.

MAJURO ATOLL: D. 12684, Sta. 6.

JALUIT ATOLL: D. 13096, Sta. 17; D. 13117, Sta. 19.

Champia parvula (Ag.) Harvey 1853: 76; Dawson 1954: 443, fig. 52c. *Chondria parvula* C. Agardh 1824: 207 (Cadiz, Spain)

MAJURO ATOLL: D. 12684b, D. 12695, Sta. 6.

ARNO ATOLL: H. 9255, Sta. 24.

Champia vieillardii Kützing 1866, Tab. Phyc. 16: 14, pl. 37e, f (New Caledonia); Dawson 1954: 443, figs. 52e, 53

JALUIT ATOLL: D. 13011, Sta. 12. This is but a small fragmentary specimen, but nevertheless a distinctive record. The plant reported from Truk Atoll and illustrated by Okamura (1906: 10, figs. 7–8) as *Champia compressa* is most probably this species.

Chrysymenia kairnbackii Grunow, prox.

JALUIT ATOLL: D. 13010a, D. 13025, Sta. 12. Although they are very small, these correspond in habit with *C. kairnbackii* as illustrated by Yamada and Segawa 1953: 111, fig. 4 from Ponape, and clearly are unlike their *C. okamurai*. The few cystocarpic plants are much like Weber van Bosse's figures and description (1928: 469) but with fewer rhizoids below the cystocarp and with no rhizoids in the cavity. Whether these differences are significant must await the collection of more ample material and comparison with both Siboga specimens and Grunow's type.

Coelarthrum boergesenii Weber van Bosse 1928: 473, figs. 207–208 (Borneo Bank)
Fig. 47

ARNO ATOLL: H. 9623, Sta. 24. Only a single small example of this species is present, but it is in complete agreement in size, shape, structure and anastomoses of the branches with the Weber van Bosse plant. Our specimen came from the under surface of an

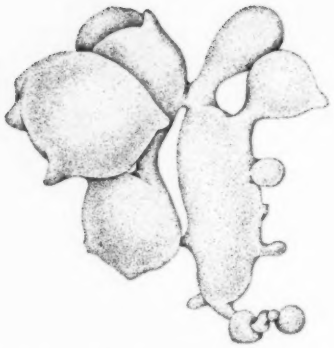

FIG. 47. *Coelarthrum boergesenii:* The entire specimen under H. 9623, × 6.

overhanging coral on the reef and agrees with her forma *minima* even as to having the "algue parasite filamenteus verte parmi les cellules de ses articles ou vésicules" as mentioned in the description of the type.

Botryocladia skottsbergii (Børgesen) Levring 1941: 645; G. Feldmann 1945: 55. *Chrysymenia skottsbergii* Børgesen 1924: 307, figs. 49–50 (Easter Island). *Botryocladia kuckuckii* (Weber van Bosse) Yamada and Tanaka 1938: 466, figs. 8–9; Taylor 1950: 135

Fig. 48

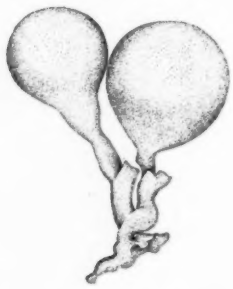

FIG. 48. *Botryocladia skottsbergii:* A small example from H. 9364, × 5.

ARNO ATOLL: H. 9384, Sta. 26; H. 9685b, Sta. 25.

Rhodymenia anastomosans Weber van Bosse 1926: 150, fig. 39 (Kei Islands, Doe-Roa, at 20 meters)

Fig. 49

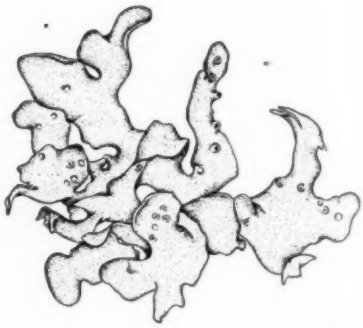

FIG. 49. *Rhodymenia anastomosans:* A cystocarpic plant of D. 13120 showing the repent habit and "anastomosing" branches, × 2.

JALUIT ATOLL: D. 13120, Sta. 19. Both antheridial and carposporic specimens are present and show good agreement with this little known species heretofore reported but once.

Lomentaria hakodatensis Yendo 1920: 6 (Japan). *Lomentaria sinensis* Howe 1924: 139, pl. 1, fig. 1

Fig. 50

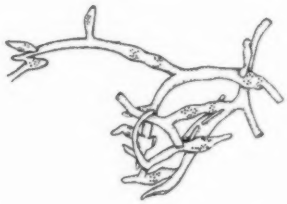

FIG. 50. *Lomentaria hakodatensis:* Part of a clumping tetrasporic example of D. 12616, × 5.

KWAJALEIN ATOLL: D. 12616, Sta. 2. This tetrasporic material is in excellent agreement with this species as known from China, Japan, and from Pacific Mexico.

JALUIT ATOLL: D. 13015, Sta. 12; D. 13165, Sta. 23. All tetrasporic.

Antithamnion lherminieri (Crouan and Crouan) Nasr 1941: 66, figs. 9–10. *Callithamnion lherminieri* Crouan and Crouan, in Mazé and Schramm 1870–77: 144. *Antithamnion antillanum* Børgesen 1915–20: 226, figs. 213–216

Fig. 51

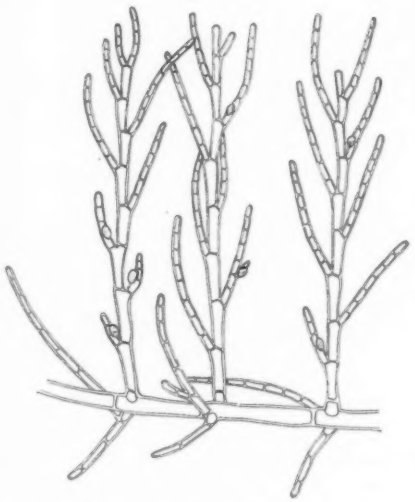

FIG. 51. *Antithamnion lherminieri:* Part of a plant of D. 13044a, × 100.

JALUIT ATOLL: D. 13044a, D. 13050b, Sta. 13; D. 13164, Sta. 23.

Ceramium gracillimum var. **byssoideum** (Harv.) G. Mazoyer 1938: 323; Dawson 1954: 448, fig. 55e, f. *Ceramium byssoideum* Harvey 1853: 218 (Key West, Florida); Taylor 1950: 138

KWAJALEIN ATOLL: D. 12554b, D. 12581, Sta. 1; D. 12599, Sta. 2; D. 12672, Sta. 5.

MAJURO ATOLL: D. 12720a, lagoon side, Enierippu Island; D. 12761, Sta. 9; D. 12791, Sta. 11.

JALUIT ATOLL: D. 13019, D. 13026, Sta. 12; D. 13049, Sta. 13; D. 13113, Sta. 19.

ARNO ATOLL: H. 9581f, Sta. 25.

The specimens of these many collections are variable. Some of them, such as D. 12599, have abundant gland cells and solitary sporangia which, standing alone, would distinguish them from the Pacific Mexican *Ceramium masonii* Dawson (1950*b*: 126, pl. 2, figs. 11–12). Others, however, such as D. 12672, show few or no gland cells and have whorled, involucrate sporangia as in *C. masonii*, suggesting that only a single, widespread, variable species is involved.

Ceramium mazatlanense Dawson 1950*b*: 130, pl. 2, figs. 14–15 (Mazatlán, Mexico); Dawson 1954: 448, fig. 55g–j

JALUIT ATOLL: D. 13027, Sta. 12. Agrees excellently with the tetrasporic type.

ARNO ATOLL: H. 9165a, H. 9627a, Sta. 24; H. 9588, Sta. 25.

Ceramium fimbriatum Setchell and Gardner 1924: 777, pl. 26, figs. 43, 44 (Gulf of California, Mexico); Dawson 1954: 446, fig. 55a

KWAJALEIN ATOLL: D. 12577, Sta. 1.

JALUIT ATOLL: D. 13110, Sta. 18. Only a small but distinctive bit noted.

Ceramium camouii Dawson 1944: 319, pl. 51, figs. 2–3 (Turner's Island, Gulf of California, Mexico); Dawson 1950b: 129

Fig. 52

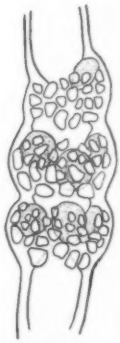

FIG. 52. *Ceramium camouii:* A small part of a tetrasporic axis of H. 9527a, showing the tumid nodal whorls, × 200.

ARNO ATOLL: H. 9527a, Sta. 24. A few branches of the specimens of this collection bear tetrasporangia in the characteristic strongly tumid whorls unlike the solitary ones of *C. serpens*. Vegetatively *C. camouii* and *C. serpens* are similar and may not readily be distinguished unless found in tetrasporic condition. This species has been reported from both tropical and subtropical areas on the coast of Pacific Mexico, but not heretofore in the central Pacific.

Ceramium serpens Setchell and Gardner 1924: 775, pl. 27, fig. 58 (Gulf of California, Mexico)

Fig. 53

FIG. 53. *Ceramium serpens:* Part of a tetrasporic plant of the type collection, × 125 (redrawn from Setchell and Gardner).

MAJURO ATOLL: D. 12717a, lagoon side of Enierippu Island. This tetrasporic material is identical with the Mexican type.

JALUIT ATOLL: D. 13044, Sta. 13; D. 13074, Sta. 15.

ARNO ATOLL: H. 9246a, H. 9448a, Sta. 24.

Ceramium clarionense Setchell and Gardner 1930: 170, pl. 7, figs. 25–27 (Isla Clarión, Revillagigedo Archipelago, Mexico); Dawson 1954: 448, fig. 55k

MAJURO ATOLL: D. 12722, lagoon shore of Enierippu Island. Very well-developed material. D. 12782, D. 12791a, Sta. 11.

Ceramium huysmansii Weber van Bosse 1923: 322, fig. 115a, b (Indonesia); Dawson 1954: 446, fig. 55d

ARNO ATOLL: H. 9165, H. 9467, Sta. 24. Tetrasporic material among these specimens is manifestly like the Indonesian and Vietnamese plants cited above. Børgesen has reported this species from Mauritius under the name *Ceramiella*. It also seems clearly to be the same as the plant described and figured by Setchell (1926: 104, pl. 21, fig. 1–2) as *Bostrychia exigua*.

Centroceras minutum Yamada 1944a: 42 (Ant Atoll, Ponape, Caroline Islands)

Fig. 54

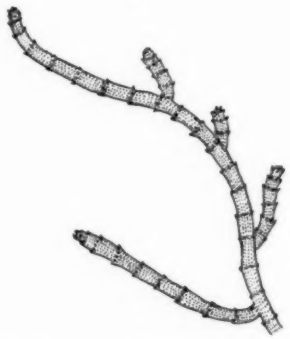

FIG. 54. *Centroceras minutum:* Habit of part of a creeping plant of H. 9611, × 10.

ARNO ATOLL: H. 9611, Sta. 29. This material of a small, creeping, irregularly branched, non-forcipate *Centroceras* agrees excellently with Yamada's description. Although it would

appear hazardous to recognize another *Centroceras* with a number of characters in common with the widespread and variable *C. clavulatum*, the habit and general lack of dichotomous branching do seem to distinguish this small plant. H. 9630, Sta. 24, represents quite abundant material creeping on *Valonia aegagropila* in company with *C. apiculatum*. Note that dichotomous branching is not infrequent in certain well-developed free branches.

Centroceras apiculatum Yamada 1944*a*: 42 (Ant Atoll, Caroline Islands) Fig. 55

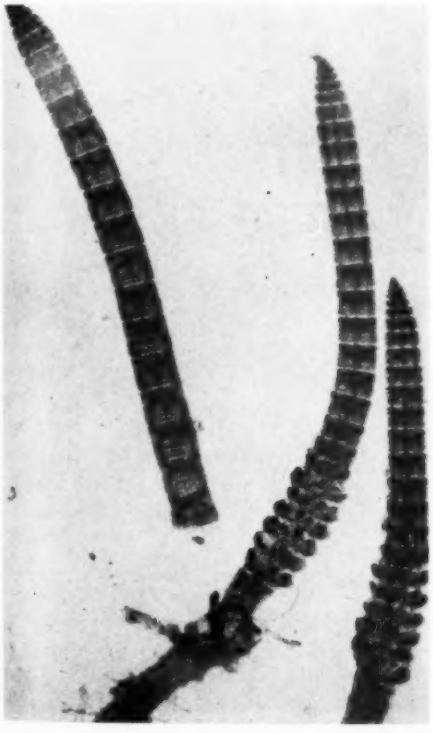

FIG. 55. *Centroceras apiculatum:* Terminal portions of a sterile axis and two tetrasporangial axes of H. 9543a, × 68.

ARNO ATOLL: H. 9284a, H. 9527b, H. 9543a, H. 9630b, Sta. 24. This material, part of which is tetrasporic, agrees in all respects with Yamada's description.

Centroceras clavulatum (Ag.) Montagne, in Durieu 1846: 140; Taylor 1950: 139; Dawson 1954: 446, fig. 54b. *Ceramium clavulatum* C. Agardh, in Kunth 1822: 2 (Peru)

KWAJALEIN ATOLL: D. 12578a, Sta. 1. This material is mostly of f. *inerme* (Kütz.) Piccone. D. 12604, D. 12636, Sta. 2; D. 12650, Sta. 3.

MAJURO ATOLL: D. 12693, Sta. 6; D. 12737, Sta. 7. This is f. *inerme* (Kütz.) Piccone. D. 12749, Sta. 8.

JALUIT ATOLL: D. 13034a, D. 13053, Sta. 13.

Crouania minutissima Yamada 1944*a*: 41 (Ant Atoll, near Ponape, Caroline Islands) Fig. 56

FIG. 56. *Crouania minutissima:* Habit of a plant from H. 9585, × 20.

ARNO ATOLL: H. 9585, H. 9594a, Sta. 25. The abundant material of this beautiful little plant agrees excellently with the description given by Yamada of the type from nearby Ponape, except that the primary branchlets appear not to occur in groups of four at "every whorl." In the present specimens there appear often to be only three such primary

branchlets in a whorl. Such variation occurs also in the type species, *C. attenuata*.

Wrangelia argus (Mont.) Montagne 1856: 444; Dawson 1954: 444, fig. 54g. *Griffithsia argus* Montagne 1840*a*: 176, pl. 8, fig. 4 (Canary Islands)

MAJURO ATOLL: D. 12748, Sta. 8; D. 12774, Sta. 10.

ARNO ATOLL: H. 9592f, H. 9598f, H. 9600a, Sta. 25.

Spyridia filamentosa (Wulf.) Harvey, in Hooker 1833: 337; Taylor 1950: 139; Dawson 1954: 444, fig. 54i, j. *Fucus filamentosus* Wulfen 1803: 63 (Europe)

KWAJALEIN ATOLL: D. 12608, Sta. 2; D. 12665, Sta. 4.

MAJURO ATOLL: D. 12761a, Sta. 9; D. 12781, Sta. 11.

Spermothamnion saccorhiza (Setch. and Gard.) Feldmann-Mazoyer 1942: 16. *Pleonosporium saccorhiza* Setchell and Gardner 1930: 168, pl. 10, fig. 39 (on *Codium*, Isla Guadalupe, Mexico)

Fig. 57

KWAJALEIN ATOLL: D. 12571, Sta. 1; D. 12612, Sta. 2. Both on *Codium*.

Griffithsia tenuis C. Agardh 1828: 131 (Venice, Italy); Dawson 1954: 450, fig. 56e

JALUIT ATOLL: D. 13018b, Sta. 12; D. 13034, Sta. 13.

Griffithsia metcalfii Tseng 1942: 111, figs. 5–9 (Hainan, China); Dawson 1954: 450, fig. 56 k, l; Abbott 1946: 440, pl. 2, figs. 3–6

KWAJALEIN ATOLL: D. 12610, Sta. 2. This material is tetrasporic and agrees with Abbott's key and figures.

Martensia fragilis Harvey 1854: 145 (Ceylon); Svedelius 1908: 11, figs. 8, 10–28, pl. 1, figs. 1–10, pl. 2, figs. 6–10, pls. 3–4; Okamura 1916: 11

Fig. 58

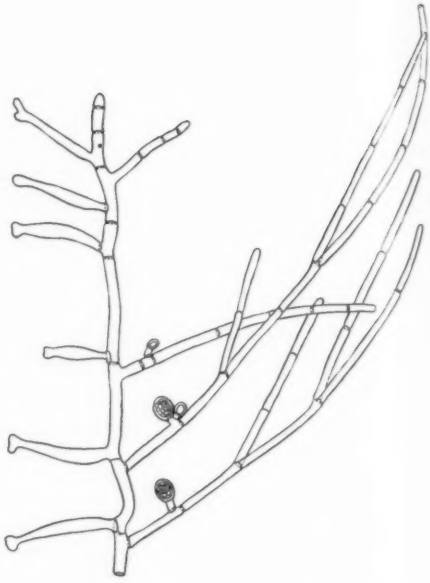

FIG. 57. *Spermothamnion saccorhiza:* Part of a plant of the type collection, × 37.5 (redrawn from Setchell and Gardner).

FIG. 58. *Martensia fragilis:* A young male plant showing early development of network, × 4 (redrawn from Svedelius).

ARNO ATOLL: H. 9059a, Sta. 25. Only a few fragmentary specimens are present, but in size, habit, and structure they appear to agree with this species which Okamura has reported from Truk Atoll.

Caloglossa adnata (Zanardini) De Toni 1900: 730; Dawson 1954: 451, fig. 58b. *Delesseria adnata* Zanardini 1872: 141, pl. 5B, figs. 1–3 (Sarawak, Borneo)

JALUIT ATOLL: D. 13084b, Sta. 16.

Caloglossa leprieurii (Montagne) J. Agardh 1876: 499; Taylor 1950: 140. *Delesseria leprieurii* Montagne 1840*b*: 196, pl. 5, fig. 1a–f (French Guiana)

Fig. 59

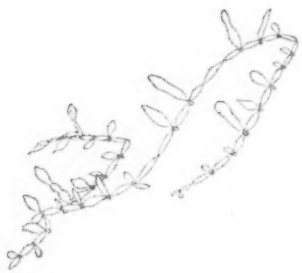

FIG. 59. *Caloglossa leprieurii* f. *pygmaea:* Habit of a plant of D. 12609a growing on *Valonia*, × 4.

KWAJALEIN ATOLL: D. 12609a, Sta. 2. These minute plants on the membrane of *Valonia* correspond with the f. *pygmaea* of Post 1936: 49.

JALUIT ATOLL: D. 13058a, Sta. 13. On the surface of *Lithoporella*.

ARNO ATOLL: H. 9628a, Sta. 24; H. 9489, Sta. 28. These minute plants were growing among blue-green algae on the under side of a flat rock on the lagoon reef. They differ somewhat from those under D. 12609a as figured, in having abundant stoloniferous parts which are very narrow, even subcylindrical in part, and erect parts which are longer and narrower. Because of the great variation known to exist in this widespread species of both marine and fresh water it seems well to assign the Arno material here.

Dictyurus purpurascens Bory, in Belanger and Bory 1846: 170, pl. 15, fig. 2 (Cape Comorin, Indian Ocean); Falkenberg 1901: 675, pl. 17, figs. 10–24; Svedelius and Nygren 1946: 3–32, pls. 1–2, figs. 1–18; Taylor 1950: 143, pl. 38, fig. 1

ARNO ATOLL: H. 9524, H. 9544, Sta. 24.

Heterosiphonia wurdemannii var. **laxa** Børgesen 1915–20: 326, fig. 327 (Virgin Islands); Taylor 1950: 140 (as *H. wurdemanni*)

Fig. 60

KWAJALEIN ATOLL: D. 12568a, Sta. 1.
JALUIT ATOLL: D. 13108a, Sta. 18.
ARNO ATOLL: H. 9166, H. 9203a, H. 9444, H. 9538, Sta. 24; H. 9507, Sta. 28.

Polysiphonia tongatensis Harvey, in Kützing 1864, Tab. Phyc. 14: 14, pl. 41 (Friendly Islands); Dawson 1954: 454, fig. 60d,e

JALUIT ATOLL: D. 13065a, D. 13075, Sta. 15. All reproductive phases present.

Polysiphonia coacta Tseng 1944: 71, pl. 2 (Hong Kong, China); Dawson 1954: 456, fig. 60g, h

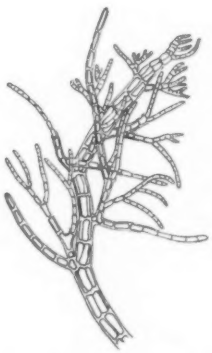

FIG. 60. *Heterosiphonia wurdemanni* var. *laxa:* An upper part of a plant of D. 12568a, to show the branching and arrangement of cells, × 25.

MAJURO ATOLL: D. 12729, Sta. 7.

ARNO ATOLL: H. 9534e, Sta. 24. The material in this mixture of turf algae is mostly 100–170 μ in diameter and in good agreement with this short-segmented Chinese species.

Polysiphonia subtillissima Montagne 1840*b*: 199 (French Guiana); Dawson 1954: 454, fig. 60c

ARNO ATOLL: H. 9514, Sta. 28. This material of a very slender species with four pericentral cells, few scar cells, and almost no trichoblasts seems to agree with similar material collected by the writer in Viêt Nam and referred to this species in accord with Tseng 1944.

Endosiphonia spinuligera Zanardini 1878: 35 (New Guinea); Falkenberg 1901: 571

Fig. 61

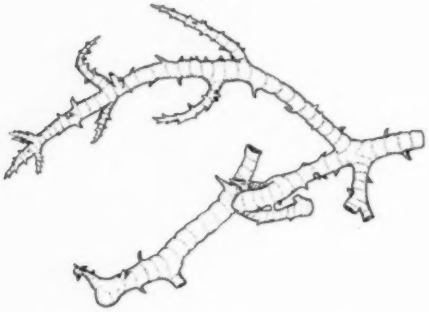

FIG. 61. *Endosiphonia spinuligera:* A small part of a plant of D. 13115, × 3.5.

JALUIT ATOLL: D. 13115, Sta. 19. These specimens seem to be in complete agreement with this species described from New Guinea.

Tolypiocladia calodictyon (Harv.) Silva 1952: 308. *Polysiphonia calodictyon* Harvey, ex Kützing 1864, Tab. Phyc. 14: 16, pl. 46, figs. a–c (Friendly Islands). Taylor 1950: 148, pl. 57, fig. 2 (as *Rochera calodictyon*)

Fig. 62

KWAJALEIN ATOLL: D. 12559, Sta. 1. Young, dwarfish material.

FIG. 62. *Tolypiocladia calodictyon:* A small upper part of a plant of H. 9243, × 6.5.

MAJURO ATOLL: D. 12784, Sta. 11.

JALUIT ATOLL: D. 13116, Sta. 19.

ARNO ATOLL: H. 9243, H. 9583, Sta. 25. Occurring in huge quantities over a large area in the sandy inner section of the lagoon reef.

Herposiphonia secunda (Ag.) Ambronn 1880: 197, pl. 4, figs. 8, 12; Howe 1920: 573, Børgesen 1930: 111, fig. 45. *Hutchinsia secunda* C. Agardh 1824: 149 (Mediterranean Sea)

Fig. 63

ARNO ATOLL: H. 9373c, Sta. 27; H. 9220, H. 9246b, H. 9258, H. 9290, Sta. 24. The plants of these collections agree with the species as interpreted by Howe (1920) who uses as a key character the fact that some of the nodes are regularly and wholly destitute of branches. The same is true of Børgesen's account. Taylor (1950: 148) reports a plant under this name from Rongelap Atoll, but his description does not agree with my specimens which have 7 to 8 pericentral cells in the main

axes, and do not have "erect branchlets at the three nodes between each two branch rudiments." His plants meet the usually accepted requirements for *H. tenella*.

Herposiphonia tenella (Ag.) Ambronn 1880: 197, pl. 4, figs. 9, 11, 13–16; Dawson 1954: 452, fig. 59a. *Hutchinsia tenella* C. Agardh 1828: 105 (Mediterranean Sea)

KWAJALEIN ATOLL: D. 12615, Sta. 2.

JALUIT ATOLL: D. 13050a, Sta. 13; D. 13103, Sta. 18; D. 13130, Sta. 19.

ARNO ATOLL: H. 9449a, H. 9534f, Sta. 24.

Lophosiphonia villum (J. Ag.) Setchell and Gardner 1903: 329; Hollenberg 1942: 535, figs. 11–13. *Polysiphonia villum* J. Agardh 1863: 941 (Tropical America)

Fig. 64

ARNO ATOLL: H. 9446, H. 9467b, Sta. 24. In these specimens the rhizoids are not cut off by a cross wall and are, thus, in agreement with the species as interpreted by Hollenberg and different from the superficially very similar *L. bermudensis*.

FIG. 63. *Herposiphonia secunda:* Part of a tetrasporic plant showing several segments lacking erect branchlets, × 50 (redrawn from Børgesen).

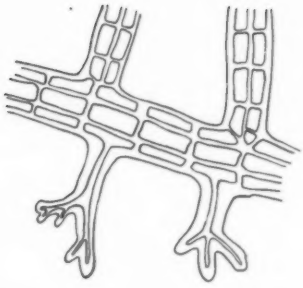

FIG. 64. *Lophosiphonia villum:* Part of a creeping basal filament showing the rhizoids which are not cut off by cross walls from the pericentral cells (H. 9446), × 150.

Lophosiphonia bermudensis Collins and Hervey 1917: 126, pl. 3, figs. 18–21 (Bermuda). Dawson 1954: 451, fig. 58f, g (as *L. villum*)

Fig. 65

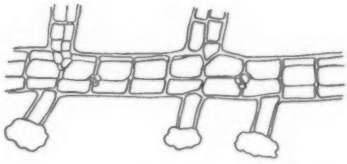

FIG. 65. *Lophosiphonia bermudensis:* A small part of a creeping basal filament showing the rhizoids distinctly cut off from the pericentral cells (H. 9598a), × 130.

KWAJALEIN ATOLL: D. 12580, Sta. 1.

JALUIT ATOLL: D. 13003, Sta. 12; D. 13041, Sta. 13; D. 13071a, D. 13073, Sta. 15; D. 13107, Sta. 18.

ARNO ATOLL: H. 9478, Sta. 28; H. 9598a, H. 9685c, Sta. 25.

The specimens cited above, of which some are in abundance and well-developed, as D. 13071a, have rhizoids conspicuously cut off by a cross wall unlike those of *L. villum*. If this character proves to be a distinctive and specific one as it now appears to be, it is probable that many of the tropical specimens referred to *L. villum* may actually belong to *L. bermudensis*. Although Collins and Hervey

made no mention of the scar cells which occur in ¼ spiral divergence and which in older axes are divided into 2–3 cells as shown in the figure above, these have been observed in typotype specimens of this species. These may in part develop into branches later.

Laurencia mariannensis Yamada 1931: 200, pl. 5, fig. b, text figs. F, G (Saipan, Marianas Islands); Taylor 1950: 144

Fig. 66

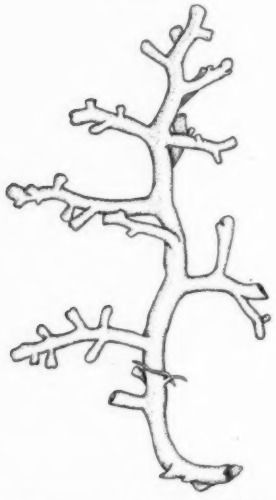

FIG. 66. *Laurencia mariannensis:* Habit of a small part of a plant of D. 12789, × 4.

MAJURO ATOLL: D. 12789, Sta. 11.

ARNO ATOLL: H. 9581, Sta. 25.

The projecting surface cells near the ends of the branches are a conspicuous and distinctive feature of this species.

Chondria repens Børgesen 1924: 300, fig. 40 (Easter Island); Dawson 1954: 460, fig. 62d, e

KWAJALEIN ATOLL: D. 12625, Sta. 2. This tetrasporic material which ranges from about 250 to 320 μ in diameter is somewhat more lax in habit than the Easter Island type as described and illustrated by Børgesen, but is otherwise very much the same. D. 12662a, Sta. 5.

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Descriptions and Redescriptions of the Hawaiian Octocorals Collected by the U. S. Fish Commission Steamer "Albatross" (2. Gorgonacea: Scleraxonia)[1]

FREDERICK M. BAYER[2]

THIS PAPER CONTINUES a general revision of the Octocorallia of Hawaiian waters, collected chiefly by the U. S. Fish Commission steamer "Albatross" during 1902. Part 1, which covered the Alcyonacea, Stolonifera and Telestacea, appeared in *Pacific Science*, volume 6, number 2 (1952). The present part commences the treatment of the Gorgonacea and considers the members of the suborder Scleraxonia, including the problematical genus *Keroeides*.

Order GORGONACEA

The limits of this order are not very clearly defined. Those forms with a distinct axis, horny or calcareous, give comparatively little trouble. Their colonies are distinctive, their gastrovascular cavities are uniformly short, and they fall conveniently into the order as it is usually defined:

Octocorals building sessile, usually tree-like colonies. Zooids uniformly with short gastrovascular cavities connected with one another by gastrodermal solenia. Colonial coenenchyme divided into an outer and an inner layer. In the outer layer ("cortex" or "rind") the sclerites are free; in the inner layer ("medulla" or "axis") the sclerites, if present, are surrounded by horny substance or are cemented together by calcareous matter to form a solid axis; or the axis may be purely horny, with or without non-spicular calcareous matter in the horny substance.

Unfortunately, there are all too many species that lack the characteristic features so commonly ascribed to the Gorgonacea. Several species long ranked in this order have recently (Verseveldt, 1940) been transferred on histological grounds to the Alcyonacea, making it difficult to distinguish clearly the former order from the latter. For all practical purposes, however, it would seem advisable to adhere more or less closely to the long-standing diagnosis of the Gorgonacea, and if a specimen shows a recognizable distinction between cortex and medulla, together with predominantly short gastrovascular cavities, to assign it to this order.

The peculiar genus Keroeides, although it has abundant spicular deposits in the outer layer of the axis, has a definite, chambered central chord and thus is clearly a holaxonian. However, it is here considered along with the Scleraxonia because of its general resemblance to them.

The order Gorgonacea is subdivided as follows:

1. The central axis is either purely horny, or horny with non-spicular (except in *Keroeides*) calcareous deposits often in coaxial

[1] Published with the permission of the Secretary of the Smithsonian Institution. Manuscript received June 23, 1955.

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layers, or of long calcareous internodes alternating with short nodes of entirely horny material; often a chambered central chord in the axis: Suborder HOLAXONIA.

2. The central axis is not wholly or largely horny, but is instead a medullar zone filled with true spicules, often distinctly different from those of the rind, more or less tightly bound together by horny or calcareous matter; if jointed, the horny nodes are filled with spicules and the internodes are composed of inseparably fused spicular sclerodermites. Medulla never with a soft, cross-chambered central chord: Suborder SCLERAXONIA.

Suborder SCLERAXONIA

The subdivision of the Gorgonacea into its two suborders is likewise not entirely satisfactory. From a practical standpoint, the line separating the Scleraxonia from the Holaxonia should be drawn between those forms with spicules in the axis cylinder and those with the calcium carbonate of the axis in strictly non-spicular form, but the natural line falls elsewhere. Thus, the genus *Keroeides*, already mentioned, should be a scleraxonian on a basis of its spicular axis but is in reality a holaxonian.

The following key may assist in the recognition of the families, each represented by a single genus, discussed in the present paper.

1. The axis consists of spongy, spicule-filled, horny nodes alternating with longer calcareous internodes made up of spicules cemented together. . Family **Melithaeidae**
1. The axis is not made up of alternating nodes and internodes 2
2. The axis is a medullar region composed of completely fused calcareous sclerodermites derived from spicules . . . . . Family **Coralliidae**
2. The axis is a medullar region composed of separable spicules bound together by horny material and sometimes by their own projections 3
3. The axis has a cross-chambered central chord; axial spicules smooth, terete, more or less flattened, rather sinuous, occasionally anastomosing. . Family **Keroeididae**
3. The axis may have numerous gastrodermal canals, especially in the proximal parts, but never a chambered central chord; axial spicules furnished with branching processes 4
4. Polyps large, exsert, with a strong, well-defined anthocodial crown and points; monomorphic; cortex set off from medulla by a ring of boundary canals . . . . . Family **Anthothelidae**
4. Polyps retractile into a thick cortex, not exsert; no strong anthocodial crown and points; dimorphic; cortex not set off from medulla by a ring of boundary canals . . . . . Family **Paragorgiidae**

Family *PARAGORGIIDAE*

DIAGNOSIS: Dimorphic Scleraxonia with medullar region penetrated to the branch tips by gastrodermal canals and not separated from the cortex by a ring of boundary canals.

Genus PARAGORGIA
Milne Edwards and Haime

Paragorgia Milne Edwards and Haime, 1857, Hist. nat. coral. 1: 190. Kükenthal, 1924, Das Tierreich 47: 28.

DIAGNOSIS: Colonies erect, often branched in one plane. Branches approximately round in cross section, usually knobby. Polyps dimorphic: autozooids large, completely retractile within low or hemispherical verrucae; siphonozooids small, in minute verrucae. Cortex with two layers, not separated from the medulla by boundary canals. Medulla perforated to branch tips by central, gastrodermal canals and smaller solenia. Spicules of the cortex chiefly capstans in the outer zone, spindles in the inner. Spicules of medulla mostly spindles or rods, coarsely spined and branched.

TYPE SPECIES: *Alcyonium arboreum* Linnaeus, by monotypy.

Paragorgia dendroides sp. nov.
Figs. 1; 2*d*

Paragorgia nodosa Nutting, 1908, U. S. Natl. Mus., Proc. 34: 569. *Nec* Koren and Danielssen, 1883, Nye Alcyonider: VII, 18, pl. 9.

DIAGNOSIS: Slender *Paragorgia* with autozooids on all sides, often clustered, in dome-like verrucae; siphonozooids on cortex surface and autozooid verrucae as minute protuberances. Cortex divided into inner and outer layers by a network of small solenia; medulla with wide, central canals and large solenia. Outer cortical sclerites chiefly octoradiate capstans with blunt sculpturing; inner cortical sclerites as warty spindles. Medulla with longer, more rudely sculptured spindles. Tentacular rhachis with longitudinal tract of pointed rods mostly arranged lengthwise.

DESCRIPTION: The specimen consists of five fragments, the largest of which is 55 mm. in height; in its thickest part, the largest branch measures 6.5 mm. in diameter. Ramification is irregular and apparently not strictly in one plane. The autozooids occur singly or in clusters and form conspicuous, dome-like verrucae 2–3 mm. in height. Several autozooids usually are clustered at the twig tips making them clavate. The siphonozooids form much smaller verrucae, about 0.5 mm. in diameter, openly scattered on the surface of the cortex and on the autozooid verrucae. The canal system is complex and agrees in general with the description of that of *Paragorgia arborea* given by Verseveldt (1940: 20). There is a fairly distinct division of the coenenchyme into a cortical rind and a medullar axis.

The salmon pink cortex (including the walls of the autozooid verrucae) is divided into an inner and an outer layer by a network of cortical solenia that communicate between the zooids; smaller solenia penetrate both inner and outer zones of the cortex. In the peripheral layer the typical sclerites are small capstans, chiefly octoradiates, 0.06–0.1 mm. in length (Fig. 1*b*). The cortical zone inside the solenial network is a thin, in places discontinuous, layer best developed in the verrucae, which contains warty spindles 0.2–0.23 mm. in length (Fig. 1*c*). The spicules of the cortex are pale pink.

The medulla, which is generally much paler in color than the cortex, is perforated by large solenia and, at the center, by three of four wide, longitudinal, gastrodermal canals, all intercommunicating through a system of smaller solenia. The pale peripheral part of the medulla contains large, colorless, coarsely warted rods up to about 0.4 mm. in length (Fig. 1*f*), and a very sparse scattering of pink spindles like those of the inner cortex. Immediately surrounding the large central canals is a pink area filled with colored sclerites shaped like those of the surrounding tissues but somewhat shorter and more rudely sculptured (Fig. 1*e*).

The autozooids have eight interseptal tracts of spicules extending up the tentacle bases and along the rhachis of the tentacles. Below the tentacles the sclerites are arranged obscurely *en chevron* between the septal insertions, becoming mostly longitudinal on the tentacle backs (Fig. 2*d*). Spicules do not extend into the pinnules, but the endodermal layer of the tentacles, including the pinnules, is charged with minute birefringent granules. The characteristic octoradiate capstan is a common form in the anthocodiae, but the principal spicule type in the tentacles seems to be the bluntly pointed rod with conical warts (Fig. 1*a*). There are also minute rods with spiny ends, a few crosses, and double forms.

HOLOTYPE: U.S.N.M. No. 25357. Ukula Point, Kauai, bearing S. 82°30′E., 13.1 miles distant, in 423–438 fathoms; fine coral sand, foraminiferans, rock; bottom temperature 41.0° F. June 24, 1902. "Albatross" station 4030.

REMARKS: The Hawaiian material was originally listed by Nutting under the name *Paragorgia nodosa* Koren and Danielssen. That species is generally considered to be identical with *Paragorgia arborea* (Linnaeus), and the original figures of the spicules of *P. nodosa* tend to support such a conclusion. Although it is impossible to decide if the Hawaiian "*Paragorgia nodosa*" is the same as the "*Paragorgia nodosa*" recorded by Nutting (1912) and Kinoshita (1913) from Japan (their specimens are lost), it is certainly not *P. arborea* (see Fig. 2). The Hawaiian material may prove to be the same as one of Kinoshita's provisionally described species, *Paragorgia tenuis* and *P. granulosa*, but, without reference to type material, this is another question that must go unanswered. During a recent visit to Tokyo I was unable to locate Kinoshita's type specimens of *Paragorgia* among the collections of the Zoological Institute, Tokyo University, where many of his types are preserved. The only course is to establish the Hawaiian specimen as a new species until additional material is available to clear up the problem.

Family *CORALLIIDAE*

This distinctive family of scleraxonians is unique in possessing an unjointed axial cylinder, or medulla, of solid calcium carbonate. According to recent authors, it contains but two valid genera. These may be separated thus:

Among the spicules there are numerous regular capstans: Genus *Corallium* Cuvier

Among the spicules there are rods, plates, and irregular forms, but no capstans: Genus *Pleurocoralloides* Moroff

For the coralliums proper, J. E. Gray (1867) proposed the use of three genera based upon the form of verrucae and the manner of branching: *Corallium*, for *C. rubrum; Pleurocorallium*, for *C. secundum;* and *Hemicorallium*, for *C. johnsoni*. In regard to spicules, *C. secundum* and *C. johnsoni* differ widely from *C. rubrum*, the former two have double clubs whereas the latter has only capstans. On this account, Ridley (1882) later recognized *Pleurocorallium* (including *Hemicorallium*) as distinct from *Corallium*. Most modern workers, however, recognize only *Corallium*, with *Pleurocorallium* and *Hemicorallium* as junior subjective synonyms.

The genus *Pleurocoralloides* Moroff, originally described from Japan, is not thus far known from the Hawaiian Islands.

Genus CORALLIUM Cuvier

Madrepora (pars) Linnaeus, 1758, Syst. Nat. Ed. 10, 1: 797.

Corallium [ächte rothe Steincoralle] Müller in Knorr, 1766, Delic. Nat. 1: 7, pl. A I, figs. 1, 2; p. 23, pl. A VII, fig. 1; p. 24, pl. A VIII, figs. 2–4; p. 127 (pars); nec pp. 9, 10, 11, 12, 13, 25, 128. [The generic names published in this work, though cited both by Neave, *Nomenclator Zoologicus*, and by Schultze, *Nomenclator Animalium*, are unavailable as the work is non-binominal.]

Isis (pars) Linnaeus, 1767, Syst. Nat. Ed. 12, 1 (2): 1288.

Nec *Isis* Linnaeus, 1758, Syst. Nat. Ed. 10, 1: 799.

Nec *Corallium* Burman, 1769, Index alter Herb. Amb. p. [3]. [= *Isis* Linnaeus, 1758.]

Corallium Cuvier, 1798, Tabl. élém.: 673. Lamarck, 1801, Syst. anim. s. vert.: 378. Gray, 1867, Zool. Soc. Lond., Proc.: 126. Ridley, 1882, Zool. Soc. Lond., Proc.: 221. Kishinouye, 1904, Imp. Fish. Bur. Tokyo, Jour. 14: 20. Hickson, 1907. Siboga Exped. Monog. $13c^1$:2.

Hemicorallium Gray, 1867, Zool. Soc. Lond., Proc.: 126.

Pleurocorallium Gray, 1867, Zool. Soc. Lond., Proc.: 126. Ridley, 1882, Zool. Soc. Lond., Proc.: 221. Johnson, 1899, Zool. Soc. Lond., Proc.: 57.

As can be seen from the synonymy above, the name *Corallium* has a rather motley history. It is an old name of dubious origin, going back to the ancient Greeks, classically applied to the red coral of commerce, the

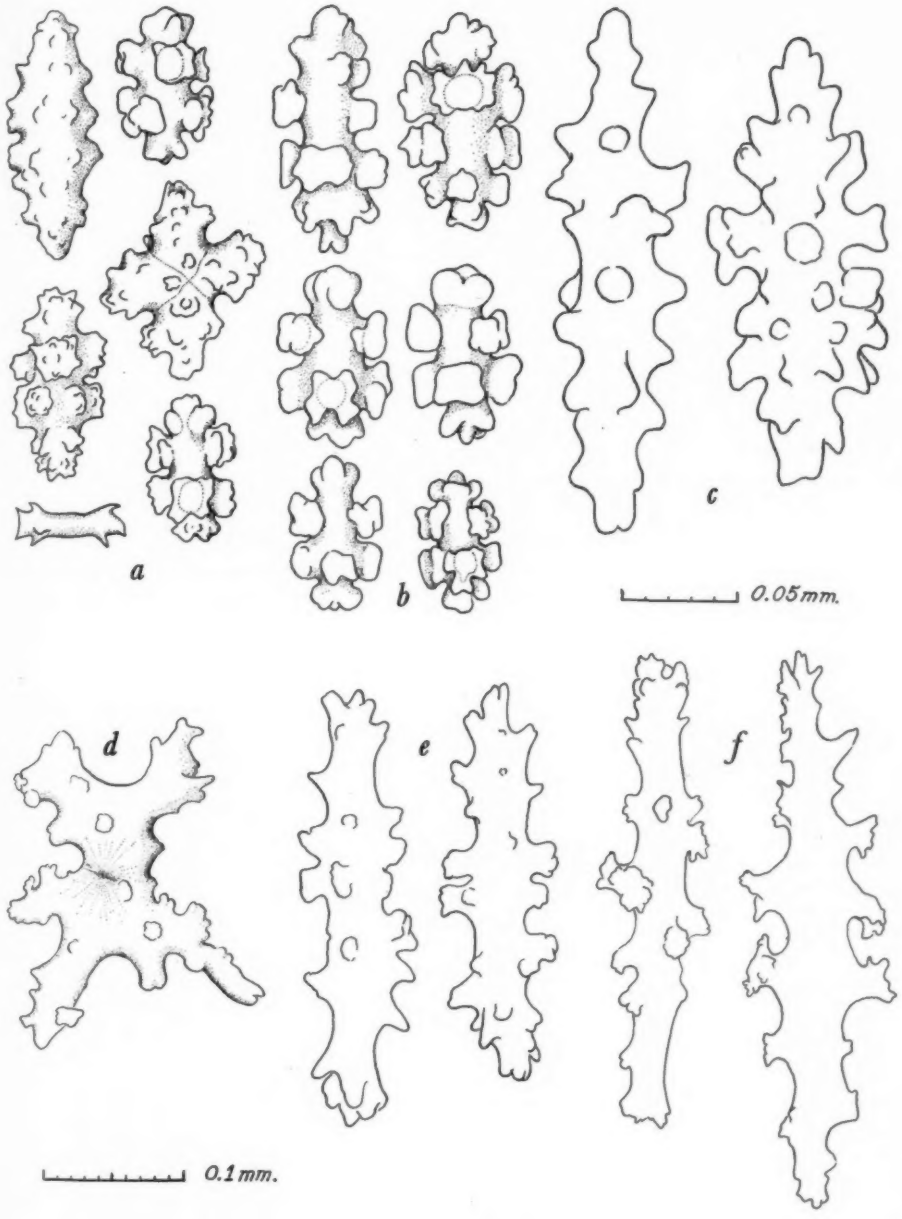

FIG. 1. *Paragorgia dendroides* sp. nov. Spicules of: *a*, Anthocodia; *b*, outer cortex; *c*, inner cortex; *d*, medulla; *e*, medulla surrounding main stem-canals; *f*, peripheral zone of medulla. Scale at *c* applies to *a–c*; scale at *d* applies to *d–f*.

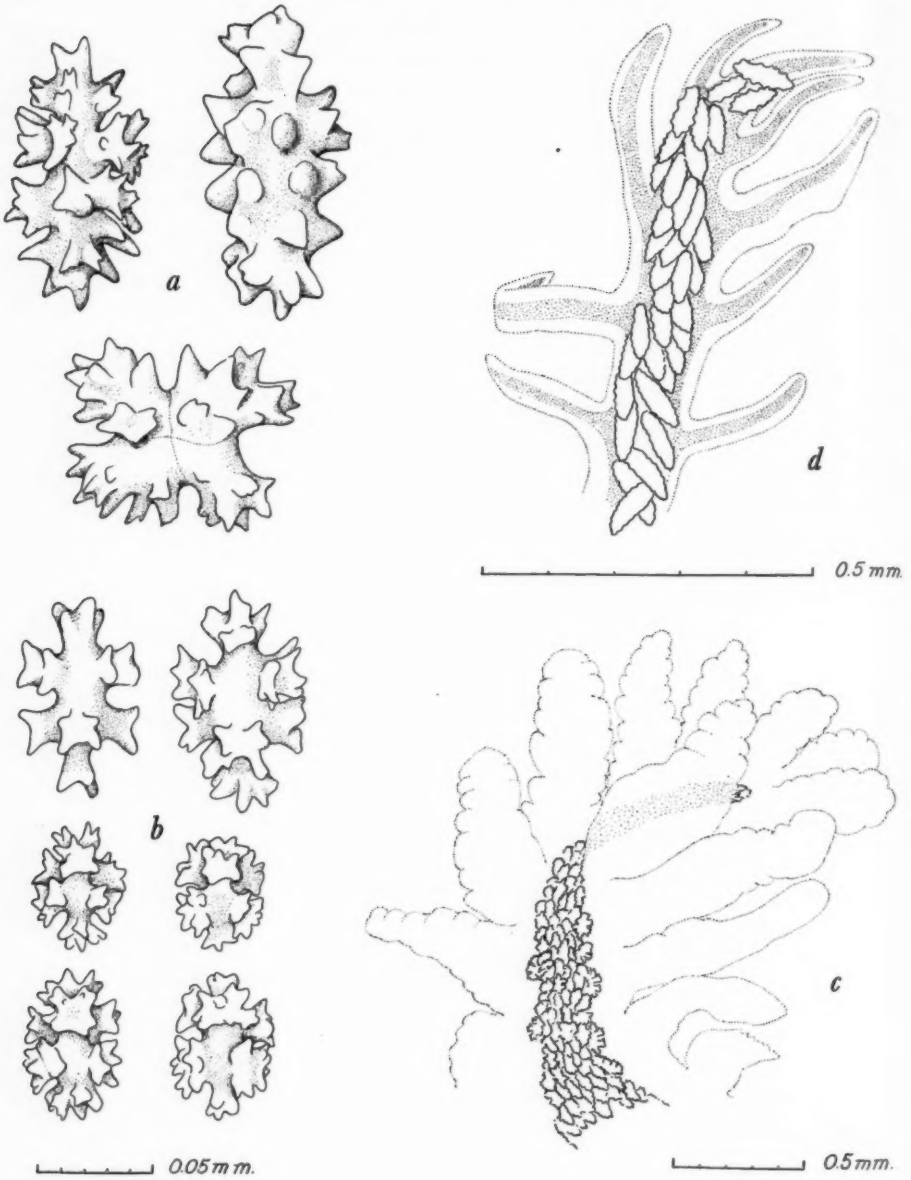

FIG. 2. *a–c*, *Paragorgia arborea* (Linnaeus). *a*, Spicules of anthocodia; *b*, spicules of outer cortex; *c*, tentacle (the stippled area indicates the course of the spicular tract where it is concealed by a pinnule). *d*, *Paragorgia dendroides* sp. nov., tentacle (the stippled area indicates distribution of miliary granules). Scale at *b* applies to *a* and *b*; scales at *c* and *d* to those figures only.

"true red stony coral." Unfortunately, one of the applications of the name *Corallium* to a different coral (Burman, 1769) antedates Cuvier's publication of it in the usual sense by almost 30 years and thus threatens the time-honored usage of the name. If the generic names in Burman's Index to the *Herbarium Amboinense* are nomenclaturally available, *Corallium* Cuvier must be conserved by the International Commission on Zoological Nomenclature or disappear as a junior synonym of *Isis* Linnaeus.

DIAGNOSIS: Dimorphic Scleraxonia with solid axis composed of calcareous sclerodermites derived from spicules. Cortical spicules are modified capstans with six, seven, or eight radii, double clubs derived from capstans, spindles, rods, crosses, and irregular forms.

TYPE SPECIES: *Madrepora rubra* Linnaeus, 1758 (by subsequent monotypy, the first species being assigned by Lamarck, 1801).

REMARKS: The various species of *Corallium* are identified by the arrangement, shape, and distribution of autozooid verrucae; the manner of branching; and the types of spicules present in the verrucae and in the rind.

The character of branching is convenient for identification, since it seems to remain constant within species, but it is not a primary character in determining relationships. The differences in spiculation are useful both in determining and in relating the various species. The basic type of spicule appears to be the octoradiate capstan. It is found in most species and is the prototype of the other forms, which have been produced by the suppression, modification, and exaggeration of certain radii. Color is not always a reliable feature since it may vary within the species, but is a useful secondary character.

The types of spicules found in *Corallium* are:

1. Long rods or spindles, with more or less prominent, simple warts. This type occurs principally in the autozooid verrucae and the tentacles.

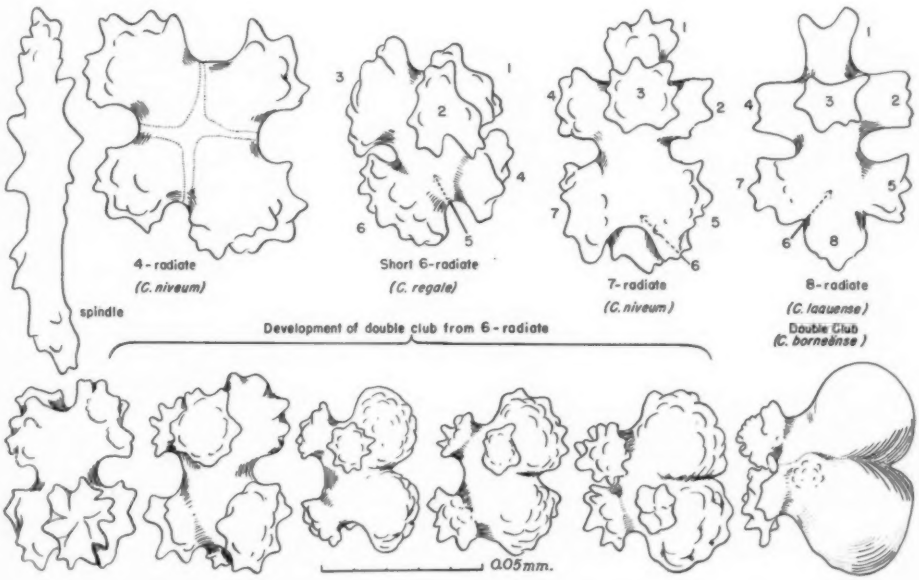

FIG. 3. Spicule types in the genus *Corallium*.

2. Multiradiate forms:
   a. Crosses or 4-radiates (Kreuze).
   b. Capstans (Gürtelstäbe), with 6, 7, or 8 radii (Sechser, Siebener, Achter). The length of the "waist" or smooth girdle may vary considerably; in a few species, the shaft of the 6-radiates may be so abbreviated that the spicules are nearly spherical (Fig. 9*g*). This is the irregular form that Kükenthal describes in *C. tricolor* ("zahlreiche unregelmässige, fast kugelige, mit dicken, ausstrahlenden Fortsätzen bedeckte Skleriten") and *C. maderense* ("unregelmässig strahlige Kugeln"), but it is not the same as the irregular type of *C. bōshūense* and *C. sulcatum*.
3. Double clubs, "double carafes" or "opera-glass spicules" (Doppelkeulen). These are derived from capstans, as shown in Figure 3.
4. Irregular forms, which are massive, lumpy sclerites of the sort found in *Corallium boshūense* and *C. sulcatum* from Japan, and in *C. ducale* from Guadalupe Island, west Mexico. This type of spicule is not found in any of the six species now known from Hawaiian waters.

Although modern students place all species of capstan-bearing Coralliidae in the one genus *Corallium*, there actually are groups of closely related species within the genus. Disregarding the sad experiences of others, I attempted anew to bring these groups into some logical arrangement. This has proved to be even more hopeless than it was half a century ago when Kishinouye studied the problem. After long and serious consideration, I can do no more than to point out certain of the relationships in the hope that some eye more penetrating than my own may detect among them a clue to the solution.

One very distinct group of species includes those that have in common double club spicules, hemispherical verrucae, and papillate rinds. Two species, *Corallium secundum* and *C. elatius*, constitute the group.

Another is the group of species that have pits in the axis beneath the autozooids. *Corallium stylasteroides* and *C. tortuosum* are very closely related, and have no double club spicules; *C. inutile* and *C. japonicum* are similar in many respects to the former pair, but have well-developed double clubs. The original precious coral, *C. rubrum*, may also belong with this group.

Perhaps the most circumscribed and homogeneous group of all is the one characterized by thick cortex, hemispherical verrucae in clusters, and double club spicules. It appears to be a very closely knit complex of species including *Corallium kōnojoi*, *C. borneënse*, *C. niveum*, and *C. pusillum*.

The final group, easily as diverse as the preceding one is uniform, is a perplexing array of species characterized by one feature: long spindles in the autozooid verrucae, which are usually tall. The species vary in form from profusely branched to only sparsely ramified; they may or may not have double club spicules; and some have cortical papillae (aside from siphonozooids) while others have not. The group includes *Corallium sulcatum*, *C. laauense*, *C. regale*, *C. abyssale*, *C. bōshūense*, *C. variabile*, *C. halmaheirense*, *C. johnsoni*, *C. tricolor*, *C. maderense*, *C. imperiale*, and *C. ducale*. *Corallium reginae* Hickson has verrucal spindles but, unlike the other species just listed, it has low, hemispherical verrucae. It is of interest to note that, of the three species having short, nearly globular 6-radiates, two (*maderense*, *tricolor*) are Atlantic while one (*regale*) is Hawaiian. *Corallium sulcatum*, *C. bōshūense* and *C. ducale*, all with massive, irregular sclerites, may form a sub-group.

Of the 20 species of *Corallium* known to inhabit the Indo-Pacific region, six are at present known from Hawaiian waters, and two from the eastern Pacific off Baja California (Guadalupe Is.). These may be separated as follows:

1. The autozooid verrucae and tentacles contain long spindles with conical processes 2

1. The autozooid verrucae and tentacles have no long spindles 6

2. Double clubs present 3
2. Double clubs not present . . . . . **laauense** sp. nov.

3. Autozooids biserial; branching dichotomous with alternate branches dominant, thus producing a zigzag stem . . . . . **abyssale** sp. nov.
3. Autozooids directed toward one face of the colony, not biserial; stem not zigzag 4

4. Branching symmetrically dichotomous, in one plane; calyces short-cylindrical or blunt-conical; massive, irregular sclerites present . . . . . **ducale** Bayer
4. Branching chiefly pinnate; calyces tall, cylindrical 5

5. Verrucae with eight grooves extending their full length. The 6–radiate spicules are of ordinary form and not almost spherical; 7-radiates are not uncommon; 8-radiates and double clubs abundant . . . . . **imperiale** Bayer
5. Verrucae grooved only in the apical part, otherwise practically smooth. The 6-radiate spicules are short, almost spherical, often with the radii much reduced; 7-radiates quite rare; 8-radiates and double clubs abundant . . . . . **regale** sp. nov.

6. Double clubs present. Axis not pitted beneath the autozooids 7
6. Double clubs not present; crosses numerous. Axis with distinct pits, often with raised and beaded rims, beneath the autozooids . . . . . **tortuosum** sp. nov.

7. Rind practically smooth, white, moderately thick. Verrucae large, often clustered in groups . . . . . **niveum** sp. nov.
7. Rind strongly papillate, salmon-pink, rather thin. Verrucae small, not clustered in groups except on twig tips . . . . . **secundum** Dana

In view of the possibility that species of *Corallium* described from other parts of the Indo-Pacific may occur also in Hawaii, the following key to all 20 species known from that area is offered as a double check upon determinations made by use of the regional key.

KEY TO THE SPECIES OF *Corallium* KNOWN FROM THE INDO-PACIFIC REGION

1. Autozooids occur all around the stems and branches 17
1. Autozooids are more or less strictly biserially arranged or predominantly face one side of the colony 2

2. Spindles with simple warts are present in the distal part of the autozooid verrucae and in tentacle backs 3
2. No spindles in autozooid verrucae . . . 12

3. Double clubs present 4
3. Double clubs not present 11

4. Massive, irregular sclerites present 5
4. Massive, irregular sclerites not present . 7

5. Ramification in one plane, openly branched in a predominantly dichotomous plan; no branchlets much smaller than the main branches arising from the front of the colony . . . . . **ducale** Bayer (Guadalupe Is., Mexcio)
5. Primary branching in one plane, but numerous slender branchlets much smaller than the main branches arising from the front of the colony 6

6. Axis white, rind yellow, not furrowed. Autozooid verrucae tall, cylindrical, not conspicuously grooved . . . . . **bōshūense** Kishinouye (Japan)
6. Axis pink, rind light red, longitudinally furrowed. Autozooid verrucae cylindrical, with eight conspicuous grooves . . . . . **sulcatum** Kishinouye (Japan)

7. Rind with double clubs and 8-radiate spicules only; no 6- and 7-radiate forms 8

7. Rind with 6-radiates as well as 8-radiates and double clubs 9

8. Autozooid verrucae hemispherical, 1.5 mm. in height. Cortex red, axis dark pink with pale concentric rings . . . . . **reginae** Hickson (East Indies)
8. Autozooid verrucae cylindrical 10

9. Outer walls of autozooid verrucae distinctly grooved their full length along the lines of septal insertion. Rind with 6-, 7-, and 8-radiates, double clubs and crosses . . . . . **imperiale** Bayer (Guadalupe Is., Mexico)
9. Outer walls of verrucae with grooves in the distal part only, and there not always distinctly. Rind with short, spheroidal 6-radiates, 8-radiates and double clubs; 7-radiates uncommon . . . . . **regale** sp. nov. (Hawaii)

10. Autozooid verrucae widely separated (8–10 mm. apart), biserial, 2 mm. in height; branching sparse, the main stem zigzag . . . . . **abyssale** sp. nov. (Hawaii)
10. Autozooid verrucae closely and irregularly placed, facing one side of the colony, 2.7 mm. in height; branching profuse . . . . . **variabile** (Thomson and Henderson) (Ceylon)

11. Spindles of verrucae reaching 0.15 mm. in length; 8-radiates frequently exceeding 0.10 mm. Rind with prominent papillae; color white. Axis white . . . . . **laauense** sp. nov. (Hawaii)
11. Spindles of verrucae about 0.09 mm. in length; 8-radiates up to 0.07 mm. Rind not papillate; color orange red. Axis pink . **halmaheirense** Hickson (East Indies)

12. Double clubs present 13
12. Double clubs not present. Spicules are 6-, 7-, and 8-radiates and crosses . . . . . **japonicum** Kishinouye (Japan)

13. Octoradiates present 14
13. Octoradiates not present 16

14. Autozooid verrucae in clusters. Rind not papillate. Twigs thick and stubby 15
14. Autozooid verrucae evenly distributed, not in clusters (except at tips of twigs). Rind densely papillate. Twigs slender, abundant on front face of colony . . . . . **secundum** Dana (Hawaii)

15. With both 6- and 7-radiates. White . . . . . **niveum** sp. nov. (Hawaii)
15. Without 6- and 7-radiates. Orange . . . . . **pusillum** Kishinouye (Japan)

16. Autozooid verrucae clustered in groups. Rind smooth. End twigs thick . . . . . **kōnoj^{O}i** Kishinouye (Japan)
16. Autozooid verrucae evenly distributed, not in groups. Rind papillate. End twigs slender . . . . . **elatius** (Japan)

17. Double clubs present 18
17. Double clubs not present 19

18. Rind very thin. Axis with pits beneath the autozooids. Other spicules are 6-radiates . . . . **inutile** Kishinouye (Japan)
18. Rind thick. Axis without pits beneath the autozooids. Other spicules are 6-, 7-, and 8-radiates and crosses . . . . . **borneënse** Bayer (Borneo)

19. Spicules only 8-radiates. Axis white . . . . . **stylasteroides** Ridley (Mauritius)
19. Many crosses present in addition to 8-radiates. Axis pink . . . . . **tortuosum** sp. nov. (Hawaii)

Corallium abyssale sp. nov.
Fig. 4; 5*a*; 7*a–d*

DIAGNOSIS: Branching asymmetrically dichotomous, especially proximad, in one plane. Autozooids biserial, verrucae with spindles. Siphonozooids in groups around autozooids. Rind papillate. Spicules: crosses, 8-radiates, double clubs; spindles in verrucae.

DESCRIPTION: The colony branches in one plane in an asymmetrically dichotomous manner, alternate branches dominating to produce

FIG. 4. *Corallium abyssale* sp. nov. The type specimen.

a zigzag, sympodial main stem; in the upper part of the colony the dichotomy becomes symmetrical and quite regular. The axis is solid, round, and smooth, 4 mm. in diameter at the lowest point, tapering to 2.5 mm. at the top (no twig tip is preserved intact). The autozooids are very widely separated and few in number, essentially biserial in arrangement although an occasional individual is out of line; the verrucae are 2 mm. in height, cylindrical, with eight longitudinal grooves in the distal half, corresponding to the septal insertions. The siphonozooids form low, wartlike protuberances in groups around the autozooids. The surface of the rind bears in addition scattered, prominent papillae that are smaller than siphonozooids and probably represent nematocyst batteries. The rind is extremely thin and is rubbed off in places.

The spicules of the autozooid verrucae include long, blunt spindles 0.12–0.13 mm. long in addition to the forms found in the rind proper. The rind spicules are 8-radiates, often coarse and clumsy-looking; stubby crosses; and double clubs with wide, depressed, weakly sculptured heads and short handles with radiating processes. In the oral disk and pharyngeal region there are spiny rodlets that appear to be derived from the 8-radiate type.

The rind (in alcohol) is pale brown, probably discolored; the axis is pale pink with a somewhat darker center; the spicules are colorless.

HOLOTYPE: U.S.N.M. No. 49326. Off Kauai: Hanamaulu warehouse bearing South 49°30′ West, 8.4 miles distant; depth, 1000–1314 fathoms, gray sand, mud, and foraminiferans; bottom temperature 36.6° F. "Albatross" station 4185, August 13, 1902.

REMARKS: *Corallium abyssale* does not closely resemble any other known species of the genus, although it is like *C. sulcatum* Kishinouye and several other species in having tall, sulcate verrucae with spindles in the spiculation.

According to the original field label, this specimen was "pink" when fresh.

Corallium regale sp. nov.
Figs. 5*c*; 7*e–g*

DIAGNOSIS: Autozooids on front and two sides of branches; verrucae tall, cylindrical, grooved only at their distal tips, containing

long, irregular spindles. Siphonozooids visible as simple pores on bases of autozooids and rind. Rind smooth. Spicules: short, globose 6-radiates, 7-, and 8-radiates (the 7's quite rare), crosses, double clubs; spindles in autozooid verrucae only. Color pink.

DESCRIPTION: The type consists of a branch with a few short twigs, insufficient to show the pattern of branching. The axis is round, smooth, and solid. The autozooids are arranged along two sides and one face, leaving the rear of the branch bare; they form tall, cylindrical verrucae 1.5–2.0 mm. in height and 1.5 mm. in diameter, 8-lobed and grooved toward the distal ends. The siphonozooids appear as small pores, sometimes in small, wart-like protuberances, on the bases of the autozooids and on the rind. The surface of the rind is not papillate, although there are surface irregularities. The rind is moderately thick, and in places expanded from the sides of the branches as recurved flaps supported by thin, calcareous outgrowths of the axis, to form tunnels inhabited by polychaete commensals.

The autozooid verrucae contain long, irregular rods 0.09–0.12 mm. in length. In both verrucae and general cortex are found 6-, 7-, and 8-radiates, the first usually short, often with the radii much reduced; the 7's of usual form, quite uncommon; the 8's also of usual form, common; also a few crosses, and double clubs with rudely sculptured heads. Small, spinose rodlets are present in the oral disk and pharyngeal region.

The spicules are pale pink by reflected light. The colony as a whole, including the axis, is pale pink.

HOLOTYPE: U.S.N.M. No. 49520. French Frigate Shoal: 23°47′10″ North, 166° 24′ 55″ West; 395–387 fathoms; coarse sand, shell, coral rock; bottom temperature 41.0° F. "Albatross" station 3973, May 29, 1902.

REMARKS: The scant material at hand gives little indication of the appearance of the entire colony. The branching is probably in one plane, as indicated by the origin of the twigs from the sides of the branch, and furthermore probably is pinnate.

Corallium regale is most closely related to *Corallium sulcatum* Kishinouye and *C. imperiale* Bayer, but differs from both in having the peculiar, almost spherical 6-radiates found also in *C. maderense* and *C. tricolor* of the Atlantic.

Of all the Hawaiian precious corals, *C. regale* has the best color and might be of commercial value if it could be fished in quantity.

Corallium laauense sp. nov.
Fig. 5*e*, *f*; 7*b–j*

DIAGNOSIS: Verrucae cylindrical, longitudinally grooved, placed on two sides and front of branches, containing long spindles. Surface of rind costate, with scattered, conical papillae. Rind with cruciform and 8-radiate spicules.

DESCRIPTION: The material at hand consists of some terminal twigs that give off lateral branchlets in one plane. The autozooids are distributed on two sides and the front of the branches; they form cylindrical, longitudinally grooved verrucae about 1 mm. tall. The siphonozooids appear as small warts with an apical pore, near the autozooid bases. The rind is longitudinally costate and bears small, conical papillae. In some of the branch axils the rind extends as a thin, membranous expansion as it may also do along the two edges of the twigs, where it may be recurved, the margins of opposite sides joining to form closed tunnels. The axis is practically round, and in the largest parts preserved shows an indication of broad, longitudinal grooving.

The spiculation consists of blunt, spinose rods or spindles up to 0.145 mm. long in the autozooid verrucae; crosses and 8-radiates in verrucae and rind; and the usual small rods in the pharyngeal region and oral disk.

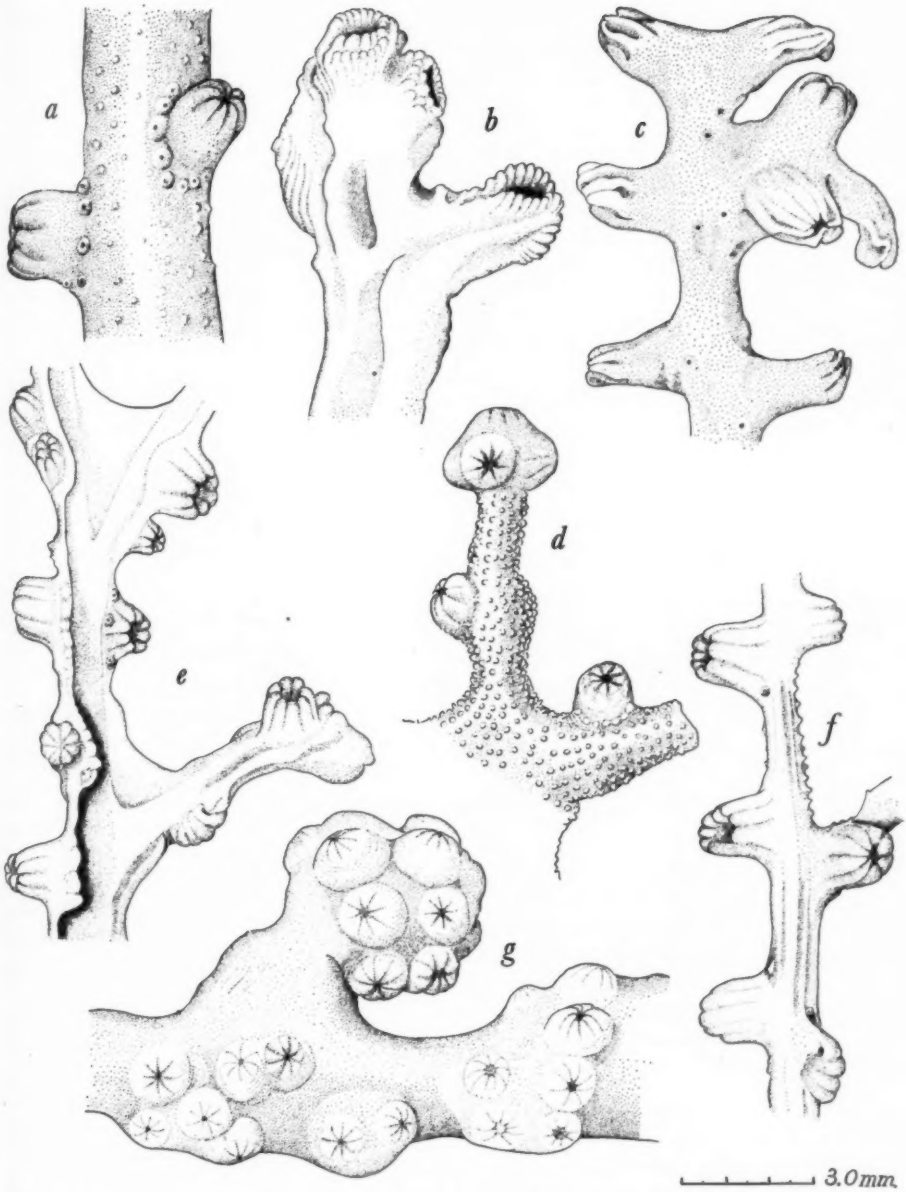

FIG. 5. *a*, *Corallium abyssale* sp. nov.; two autozooids on branch from upper part of colony; *b*, *C. tortuosum* sp. nov., tip of branch, cortex removed; *c*, *C. regale*, sp. nov., tip of branch; *d*, *C. secundum* Dana, one of the small twigs from front of colony; *e–f*, *C. laauense* sp. nov., two branchlets, *e* with the coenenchymal flaps induced by the presence of commensal polychaete; *g*, *C. niveum* sp. nov., one of the decurved, clavate twigs from front of colony; left is distad. Scale applies to all figures.

The rind is white or faintly pink; the axis is white. Spicules colorless.

HOLOTYPE: U.S.N.M. No. 49327. Molokai Island: Lae-o Ka Laau Light bearing North 46° West, 11 miles distant; depth 319–281 fathoms; broken shell and gravel; bottom temperature 43.8° F. "Albatross" station 3828, April 1, 1902.

REMARKS: In the form of its calyces and its seemingly finely divided branching, *Corallium laauense* resembles *C. sulcatum* Kishinouye, but the latter has double clubs and massive, irregular forms among its spicules.

The flaps and tunnels of rind are induced by the presence of a commensal polychaete annelid belonging to the family Polynoidae.

Corallium secundum J. D. Dana

Fig. 5*d*; 6*d*, *e*; 8*a–d*

Corallium secundum Dana, 1846, U. S. Expl. Exped., Zooph.: 641, pl. 60, fig. 1. Kishinouye, 1904, Imper. Fish. Bur., Tokyo, Jour. 14: pl. 6. Kükenthal, 1924, Das Tierreich 47: 49.

Pleurocorallium secundum Ridley, 1882, Zool. Soc. Lond., Proc.: 224, pl. 9, figs. 6–11. ?Wright and Studer, 1889, Challenger Zool. 31 (1): 186.

DIAGNOSIS: Branching in one plane, with slender, prickle-like twigs on front surface of colony. Autozooid verrucae hemispherical, distributed on front surface of branches and on the twigs. Siphonozooids near bases of autozooids. Rind prominently papillate. Spicules: crosses, 6-, 7-, and 8-radiates, and double clubs. Verrucae without long spindles.

DESCRIPTION: Colonies with the major branching in one plane, flabellate; the small twigs are slender and prickle-like and occur only on the front face of the colony. The solid axis is somewhat flattened at right angles to the major plane of ramification, and is longitudinally striated. The autozooid verrucae, which are restricted to the side of the colony that bears the short twigs, are evenly distributed and not clustered in groups except at the tips of the twigs where there may be two or three. The siphonozooids occupy small verrucae near the autozooid bases. The rind is closely papillate on all sides of the branches, but more densely so on the front. Sections have not been made to determine the nature of the papillae.

The principal spicule type is the double club; large, well-formed 8-radiates are present but not common; 6- and 7-radiates are comparatively rare. The tentacles have small 8-radiates, and in the pharyngeal region there are spiny rods and crosses of small size. The verrucae have no long spindles.

The rind is salmon pink, the verrucae not noticeably different in color. The axis is pale pink, often almost white, sometimes with a darker center. The spicules are pink by reflected light.

HOLOTYPE: U.S.N.M. No. 600. Sandwich Islands [Hawaiian Islands]. United States Exploring Expedition.

RECORDS: Pailolo Channel, between Molokai and Maui: Mokuhooniki Islet bearing North 31° West, 2.7 miles distant; depth 127–154 fathoms; broken coral, coarse gravel, rock; bottom temperature 60°–61° F. "Albatross" station 3863, April 10, 1902.

Mokuhooniki Islet bearing North 27° West, 3.3 miles distant; depth 136–148 fathoms; sand and pebbles; bottom temperature 64.8° F. "Albatross" station 3885, April 17, 1902.

REMARKS: *Corallium secundum* was long known only from the unique type, which is now decorticated. The locality "Sandwich Islands" also was held open to question. The description and figures of the spiculation given herein were made from specimens taken at two "Albatross" stations as mentioned above.

A polychaete annelid of the family Polynoidae infests this coral, causing it to produce covered tunnels along the twigs and branches.

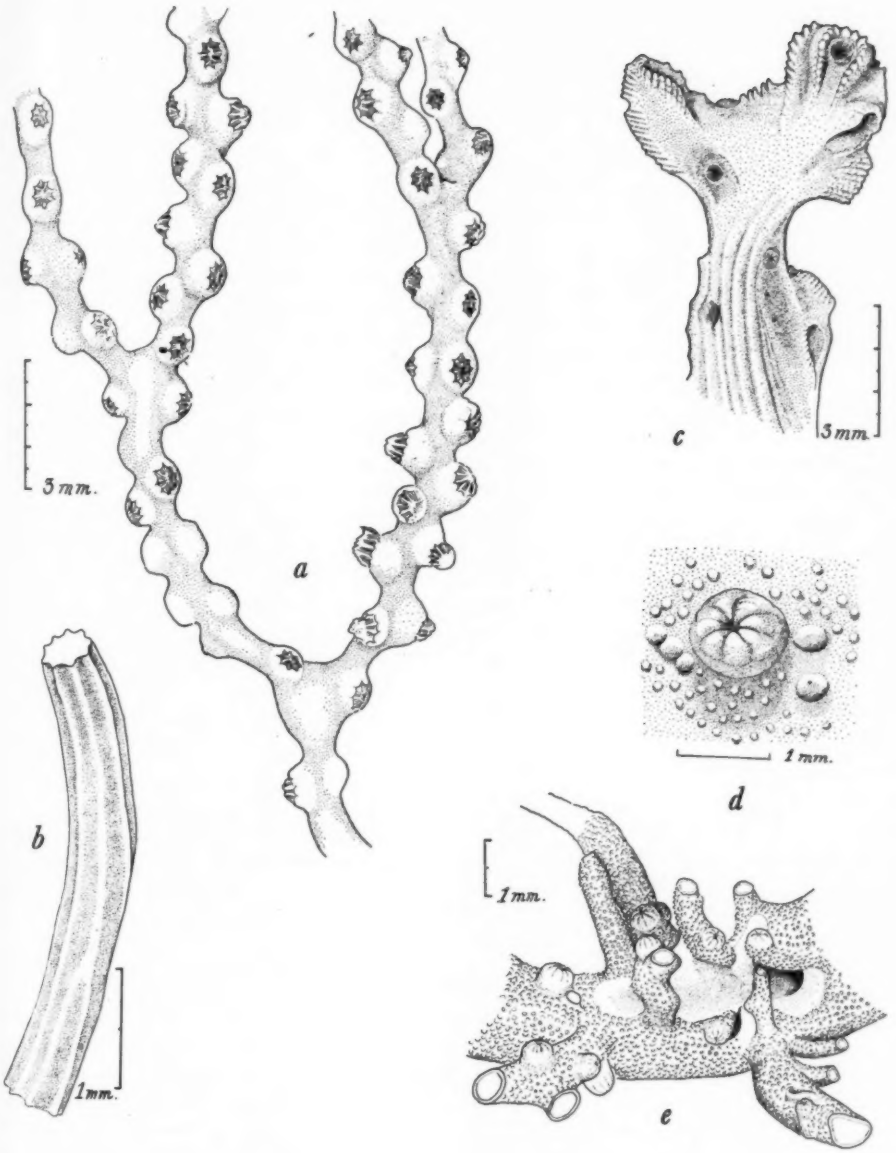

FIG. 6. *a*, *b*, *Acabaria bicolor* (Nutting): *a*, Part of the type specimen; *b*, part of axial internode, cortex removed; *c*, *Corallium tortuosum* sp. nov., branch tip with rind intact; *d–e*, *Corallium secundum* Dana, *d*, part of branch with worm tunnel; *e*, autozooid verruca with adjacent siphonozooids and cortical papillae.

Corallium tortuosum sp. nov.
Fig. 5*b*; 6*c*; 8*e–g*

DIAGNOSIS: Colonies irregularly branched in one plane. Autozooids on all sides, seated in calycular pits in the solid axis. Rind thin. Siphonozooids scattered. Spicules: crosses and 8-radiates only, in both rind and verrucae; small crosses and irregular rodlets in pharyngeal region.

DESCRIPTION: The colonies are irregularly branched, but show a definite tendency to remain in one plane. The trunk is round or oval in cross section, about 10 mm. in diameter and longitudinally grooved; the smaller branches are basically round in cross section but are more or less distorted by the autozooid calyces which indent the solid axis. The autozooids appear as raised areas on the trunk and branches; each is set in a depression surrounded by a raised rim. This rim is usually highest above and open toward the base of the colony, so that the calycular margin forms a projecting shelf over the zooid. The calyces on the twigs usually have the best developed rims, and since two are often opposed at the twig tips, a cross section of the axis there assumes a roughly x-shaped outline. The projecting calycular rim is strongly beaded and is often darker in color than the surrounding areas. The polyps do not form projecting verrucae, but retract flush across the calycular pit, and have the usual 8-rayed orifice at the center. The rind is exceedingly thin and contains few spicules, except between the longitudinal cortical solenia, each of which follows a groove in the axis. The cortex therefore appears to have lines of spicules running through it longitudinally. The siphonozooids occur as tiny verrucae between the lines of spicules in the cortex, i.e., along the solenia, especially basad from the autozooids.

The spicules are the same in both cortex and verrucae. There are two types, 8-radiates and numerous crosses. In the pharyngeal region and oral disk of the anthocodiae there are the usual minute, irregular rodlets and crosses.

The colonies are pale pink or salmon pink in color, the region surrounding the autozooids darker. Since the twig tips bear several calyces, they are customarily darker than the rest of the axis. The spicules are pink by reflected light.

HOLOTYPE: U.S.N.M. No. 49331. Pailolo Channel: Mokuhooniki Islet bearing North 35° West, 3.1 miles distant; depth 130–151 fathoms; coral, sand, shell, foraminiferans; bottom temperature 61° F. "Albatross" station 4100, July 23, 1902.

RECORDS: South coast of Molokai: Lae-o Ka Laau Light bearing North 74°30′ West, 8.1 miles distant; depth 92–212 fathoms; fine gray-brown sand; bottom temperature 67° F. "Albatross" station 3838, April 4, 1902.

Pailolo Channel: Mokuhooniki Islet bearing North 31° West, 2.7 miles distant; depth 127–154 fathoms; broken coral, coarse gravel, rock; bottom temperature 60–61° F. "Albatross" station 3863, April 10, 1902.

Pailolo Channel: Mokuhooniki Islet bearing North 27° West, 3.3 miles distant; depth 136–148 fathoms; sand and pebbles; bottom temperature 64.8° F. "Albatross" station 3885, April 17, 1902.

West coast of Hawaii: Kawaihae Light bearing North 82°30′ East, 4.1 miles distant; depth 198–147 fathoms; coral, sand, foraminiferans; bottom temperature 49° F. "Albatross" station 4045, July 11, 1902.

REMARKS: The largest specimens are about three inches high. Although the branching is mainly in one plane, twigs here and there grow out in various directions. The branches are twisted and tortuous with numerous swellings, cysts, tunnels and other deformities caused by the many epizooic and commensal animals that infest it. All specimens of *Corallium tortuosum* that I have examined are infested with a small zoanthid which pits and distorts the axis. The depressions caused by the zoanthid are distinguishable from those formed by the polyps of the *Corallium* itself

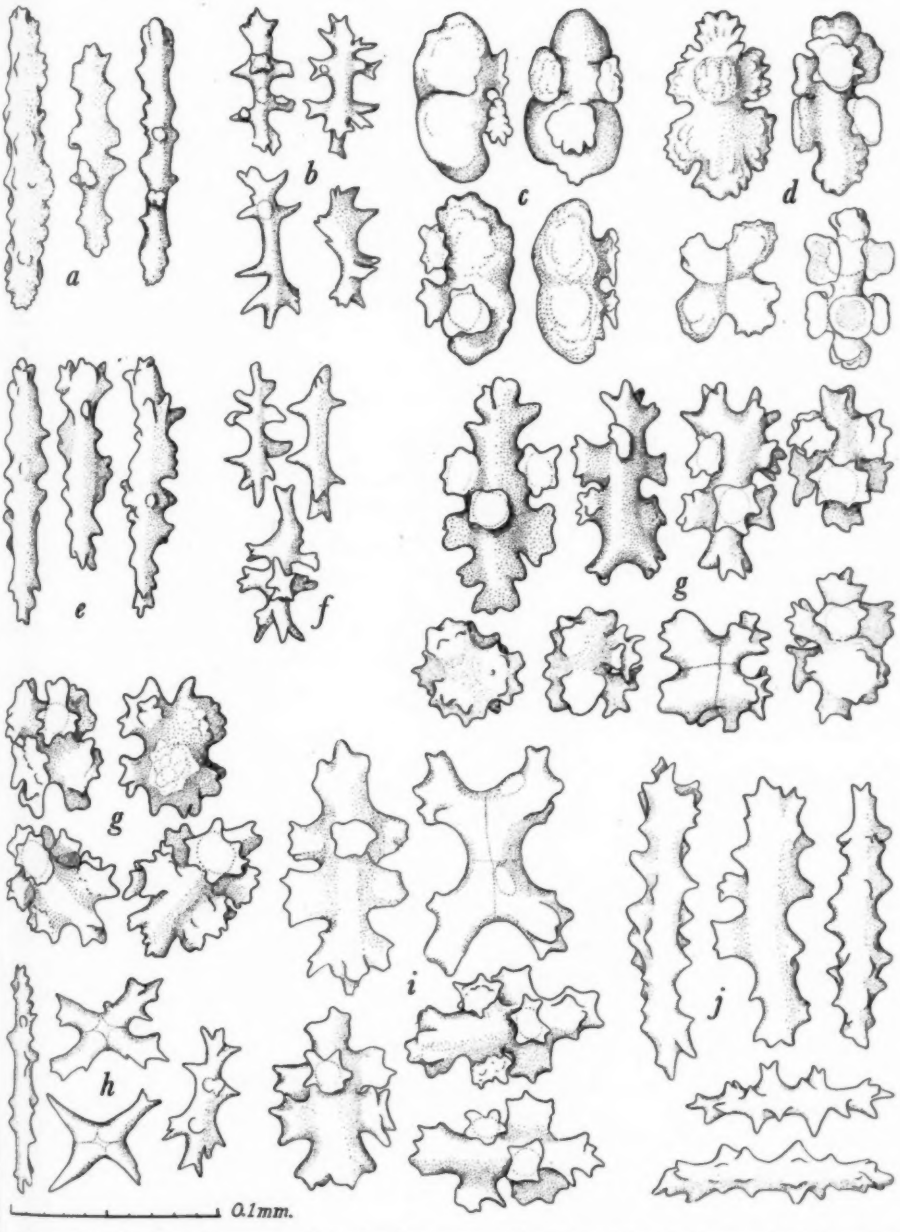

FIG. 7. Spicules of *Corallium* spp. *a–d*, *C. abyssale* sp. nov.: *a*, Verrucal spindles; *b*, spinose rods of pharyngeal region; *c*, double clubs of cortex; *d*, cross and 8-radiates of cortex. *e–g*, *C. regale* sp. nov.: *e*, Verrucal spindles; *f*, spinose rods of pharyngeal region; *g*, 6-, 7-, and 8-radiates, double clubs of cortex. *h–j*, *C. laauense* sp. nov.: *h*, Of pharyngeal region; *i*, 8-radiates and cross of cortex; *j*, verrucal spindles. Magnification of same for all figures.

by their larger size and lack of raised, beaded margin. The coral is also host to a polynoid polychaete, to which the tunnels and cavities in the axis are due. One specimen has in the main stem some chambers filled with a sponge, which may either be directly responsible for the cavities or merely occupying space left by some other inhabitant.

The Japanese *Corallium inutile* is similarly infested with actinians but, according to Kishinouye (1904: 19), the axis is not affected.

Corallium stylasteroides Ridley, 1882, is very similar in general appearance to *C. tortuosum*, but lacks the numerous cruciform spicules so conspicuous in the Hawaiian material.

Corallium tortuosum appears to be the most abundant precious coral in Hawaiian waters but, due to its small size and usually deformed axis, it probably has no commercial possibilities.

Corallium niveum sp. nov.
Fig. 5*g*; 8*b–j*

DIAGNOSIS: Colonies irregularly branched in one plane. Autozooid verrucae low, in groups, on front of colony only. Rind thick, not papillate. Spicules: 6-, 7-, and 8-radiates, crosses and double clubs, in verrucae and rind alike.

DESCRIPTION: The colonies are irregularly branched in one plane, the major branches often diverging strongly from near the base. The axis is solid, round, or oval, and longitudinally grooved; it is not pitted by the autozooids. The branches are stout, the largest ones 5–10 mm. in diameter at the base, tapering to about 2 mm. toward the tips, which are clavate. The autozooids form rather large, hemispherical verrucae with 8-rayed orifices, clustered in groups occurring almost exclusively on the front face of the colony. Each twig tip ends in a cluster of autozooids and thus assumes a clavate form. Small twigs arise from the front of the colonies, each ending in a recurved cluster of polyps which is directed toward the base of the colony. The siphonozooids are inconspicuous, appearing as simple pores in the thick rind. The surface of the rind is finely wrinkled or corrugated, but bears no papillae.

The spicules of both verrucae and cortex are 6-, 7-, and 8-radiates, crosses and double clubs. In the pharyngeal region and oral disk of the polyps there are small spiny rods and crosses.

The rind and axis both are white; the spicules are colorless.

HOLOTYPE: U.S.N.M. No. 49328. Pailolo Channel: Mokuhooniki Islet bearing North 31° West, 2.7 miles distant; depth 127–154 fathoms; broken coral, coarse gravel, rock; bottom temperature 60°–61° F. "Albatross" station 3863, April 10, 1902.

RECORD: Pailolo Channel: Mokuhooniki Islet bearing North 35° West, 3.1 miles distant; 130–151 fathoms; coral, sand, shell, foraminiferans; bottom temperature 61° F. "Albatross" station 4100, July 23, 1902.

REMARKS: *Corallium niveum* is related to *C. pusillum* Kishinouye, from Japan, which differs in lacking the 6- and 7-radiate spicules and in its orange color.

Family *ANTHOTHELIDAE*

DIAGNOSIS: Monomorphic Scleraxonia with the cortex separated from the medulla by a circle of boundary canals. Medulla but rarely perforated by solenia in the branch tips. Gastric cavities of polyps reaching to medulla but not penetrating it.

This family has been divided into three subfamilies, of which only the typical one has been reported from Hawaiian waters.

Subfamily ANTHOTHELINAE

DIAGNOSIS: Anthothelidae with elongate, pointed cortical sclerites; the medullar spicules not long needles; spindles of tentacle bases bent and often clavate. Polyps with cylindrical, projecting calyces.

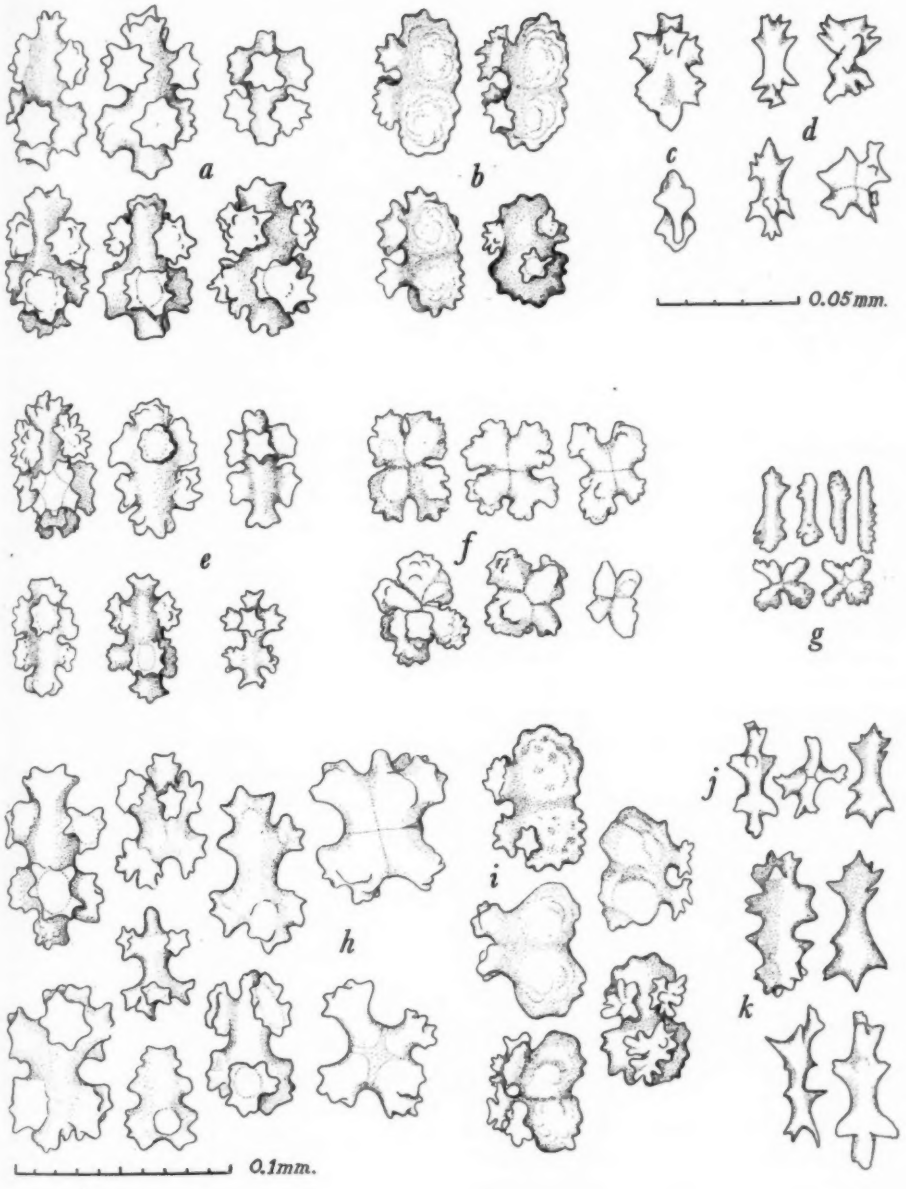

FIG. 8. Spicules of *Corallium* spp. *a–d*, *C. secundum* Dana: *a*, 8-radiates of cortex; *b*, double clubs; *c*, of tentacles; *d*, of pharyngeal region. *e–g*, *C. tortuosum* sp. nov.: *e*, 8-radiates and *f*, crosses, from cortex; *g*, of pharyngeal region. *h–k*, *C. niveum* sp. nov.: *h*, Crosses, 6-, 7-, and 8-radiates, and *i*, double clubs, of cortex; *j*, pharyngeals; *k*, pharyngeals at greater magnification. Scale at *c* and *d* applies also to *k*; scale at *h* to all others.

Genus ANTHOTHELA Verrill

Briareum (pars) M. Sars, 1856, in: Sars, Koren and Danielssen, Faun. Litt. Norv., 2: 63.

?Gymnosarca Kent, 1870, Quart. Jour. Microscop. Sci. (2) 10: 397, pl. 21.

Anthothela Verrill, 1879, U. S. Natl. Mus., Proc. 2: 199. Verrill, 1883, Mus. Comp. Zool., Bul. 11: 40. Studer, 1887, Arch. Naturgesch. 53 Jahrg. Bd. 1: 28. Broch, 1912, Norske Selsk. Skr. 2: 4. Kükenthal, 1924, Tierreich 47: 14.

?Stereogorgia Kükenthal, 1916, Zool. Anz. 47: 178. Kükenthal, 1919, Tiefsee-Exped. 13 (2): 120. Kükenthal, 1924, Tierreich 47: 39.

DIAGNOSIS: As for the subfamily.

TYPE SPECIES: *Briareum grandiflorum* M. Sars, 1856 (by monotypy).

REMARKS: The colonies are usually ramose, arising from a membranous basal expansion, which may also produce polyps. The anthocodiae are at least partially retractile into the tubular calyces. The branches are usually tortuous and not infrequently anastomose. It is not unusual to find colonies (especially the Californian species) overgrown by sponges.

Anthothela nuttingi nom. nov.
Fig. 9*a–e*

Clematissa alba Nutting, 1908, U. S. Natl. Mus., Proc. 34: 582, pl. 44, fig. 4; pl. 48, fig. 4.

Muriceides alba Kükenthal, 1924, Tierreich 47: 166.

Nec *Anthothela alba* Molander, 1929, Further Zool. Res. Swedish Antarct. Exped. 2 (3): 18.

DIAGNOSIS: Colony ramose; branches stout, clavate. Zooids on all sides; calyces tubular, not grooved. Transverse collaret and opercular points well-developed. Anthocodial spindles reaching 0.85 mm., clubs 0.65 mm.; thorny spindles of cortex up to 0.9 mm., less spiny rods up to 0.6 mm.; spiny rods and spindles of medulla up to 1.2 mm., smooth rods 0.6+ mm.

DESCRIPTION: The loosely branched main stem is stout, 6.5 mm. in diameter at its thickest part; the branches taper from 3.5 mm. in diameter at their origins to 2.5 mm. just below the swollen tips. The medullar part of the stem near the base is perforated by solenia, which diminish and seem to disappear entirely toward the branch tips. A ring of boundary canals separates the cortex from the medullar region.

The polyps are irregularly placed on all sides of the stem and branches and are more crowded at the twig tips; the anthosteles are prominent, cylindrical, ungrooved calyces; the anthocodiae have a well-differentiated opercular armature containing numerous transverse collaret rows of slender spindles which merge without noticeable break into the eight *en chevron* tracts that form the opercular points. The latter contain large clubs 0.4–0.6+ mm. long, and thorny spindles reaching 0.75 mm. The thorny spindles of the rind reach 0.9 mm. in length, and the smoother rods about 0.6 mm. The spiny rods and spindles of the medullar region attain a length of 1.2 mm., and the practically smooth rods often exceed 0.6 mm. All spicules are colorless, and the colony is ivory white throughout.

HOLOTYPE: U.S.N.M. No. 25378. Center of Moku Manu (Bird Island) bearing South 77° 30′ East, 11.1 miles distant; depth 762–1000 fathoms; white mud, foraminiferans, rock; bottom temperature 38° F.; "Albatross" station 4157, August 6, 7, 1902.

REMARKS: Molander (1929) has pointed out that Grieg's *Clavularia alba* is actually referable to *Anthothela*. This necessitates a new name for Nutting's "*Clematissa*" *alba*.

Family *MELITHAEIDAE*

DIAGNOSIS: Monomorphic Scleraxonia with a jointed axis consisting of short nodes of horny matter with numerous rod-like spicules,

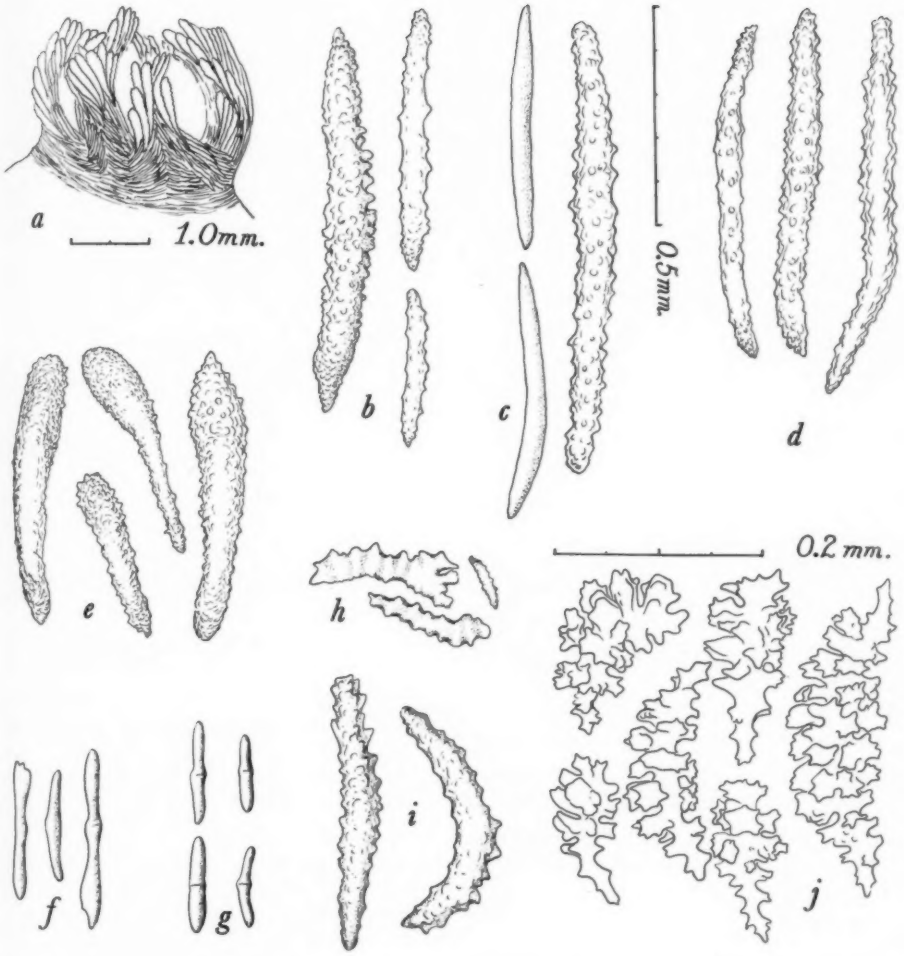

FIG. 9. *a–e*, *Anthothela nuttingi* nom. nov.: *a*, Anthocodial armature; *b–e*, spicules of cortex (*b*), medulla (*c*), anthocodia (*d*), anthocodia (*e*) (clubs). *f–j*, *Acabaria bicolor* (Nutting): Spicules of axis internodes (*f*), axis nodes (*g*), tentacles (*h*), operculum (*i*), cortex (*j*). Scale at *a* applies to that figure only; scale at *c* applies to *b–e*; scale at *j* applies to *f–j*.

and long internodes of fused spicules with little horny matter. Branching proceeds from the nodes.

REMARKS: The taxonomy of this exceedingly vexing group is badly in need of a thorough-going, modern revision. Until the time when such a study is forthcoming, the student whose sorry fate it is to encounter melithaeids is referred to Hickson's memoir on the family (1937). The separation of genera, which is very difficult, may be facilitated by the following summary of characters as given by Hickson.

a. Spicules at the surface of the coenenchym of various kinds. Blattkeulen and Stachelkeulen very rare or absent and when present few in number. Genus *Melitodes* (= *Melithaea*)
b. Spicules at the surface mainly "birotulate" in form. Genus *Melitella*
c. Numerous Blattkeulen and Stachelkeulen at the surface. Genus *Mopsella*
d. Spicules at the surface mainly long spindles, a few Stachelkeulen present in some species. Genus *Acabaria*
e. Spicules at the surface Blattkugeln forming a complete pavement-like protection for coenenchym and verrucae. Genus *Wrightella*
f. Coenenchym comparatively thick, polyps small and capable of complete retraction into the coenenchym. Internodes of axis solid. Genus *Clathraria*

Genus ACABARIA Gray

Acabaria Gray, 1859, Zool. Soc. Lond., Proc.: 484. Hickson, 1937, Zool. Soc. Lond., Trans. 23 (3): 146. Hickson, 1940, Pub. Mar. Biol. Sta. Ghardaqa 2:4.

DIAGNOSIS: Melithaeidae with cortical spiculation consisting principally of spindles and clubs that are not broad leaf-clubs.

TYPE SPECIES: *Acabaria divaricata* Gray (by monotypy).

REMARKS: Hickson (1940, p. 4) gives the following definition of the genus:

Melitodidae with comparatively slender branches bearing, in the contracted condition, prominent verrucae. Many of the littoral species dwarf in size (40–50 mms.) and very variable in color and in the form of the corallum, others reaching a larger size (250 mms. or more in height) and flabellate in form with many anastomoses and uniformly red in color. The spicules are mainly spindles and clubs. In some species, but not in others, clubs with expanded spines at one end are found. These are known as Stachelkeulen (spiny clubs or foliaceous clubs).

Acabaria bicolor (Nutting)
Fig. 6*a*, *b*; 9*f–j*

?*Melitodes variabilis* Hickson, 1905, Fauna Geogr. Maldive and Laccadive Arch. 2: 809, pl. 67, fig. 11. Thomson and Simpson, 1909, Alcyo. Investigator 2: 169.

Verrucella bicolor Nutting, 1908, U. S. Natl. Mus., Proc. 34: 597, pl. 46, figs. 6, 7.

DESCRIPTION: The axis consists of alternating, spiculiferous horny nodes and calcareous internodes. The branching is dichotomous, not in one plane, and arises from the horny nodes. The polyps are retractile into dome-like calyces 1–1.25 mm. in diameter at the base, loosely arranged in a biserial manner and inclined toward one side of the branch, leaving the other side free of polyps. The rim of the calycinal aperture is distinctly 8-lobed. The anthocodiae are provided with a distinct operculum consisting of one or two rows of curved, thorny spindles transversely placed and eight radii of 2–3 pairs of slightly bent, thorny spindles set *en chevron* beneath the tentacles. The tentacles distally contain smaller, rod-like forms with conical spines. The cortex is filled mainly with rather spiny spindles; clubs with more or less foliate projections are less abundant than the spindles. The horny nodes are filled with small, belted rods, and the internodes with longer rods firmly cemented together. The calcareous axis is marked by deep longitudinal grooves.

The rind is pinkish orange, the crown and points bright orange and the remaining anthocodial spicules bright yellow. The axis is pink, the nodes brown.

HOLOTYPE: U.S.N.M. No. 25333. Kauai: Nawiliwili Light bearing North 86° West, 1.6 miles distant; 233–40 fathoms; coarse brown coral sand and shell; bottom temperature 48.5° F. (at the greatest depth); "Albatross" station 3982, June 10, 1902.

RECORD: Beach at Manana Island, off Oahu. C. E. Cutress, March, 1955.

REMARKS: Nutting's type of *Verrucella bicolor* consists of only a few terminal branches, but is sufficient to establish beyond a doubt that it is not a member of *Verrucella*. Nutting completely overlooked the principal diagnostic features of the specimen, which are obvious without removing it from the bottle. The spicules, moreover, do not even remotely resemble those of *Verrucella*.

The specimen collected by C. E. Cutress was found thrown up on the beach and thus probably lived in quite shallow water. It agrees in most regards with the type of *bicolor*, but is darker red in color. The colony is a low, dichotomously branched bush. Although not branched in one plane, the polyps all incline toward one side of the colony, leaving the opposite surface bare.

Family *KEROEIDIDAE*

DIAGNOSIS: "Colony erect; axis rigid, consisting of a central cord and of a cortical layer composed of smooth spicules conglomerated together by a horny matrix; Axenepithel remaining only at the tip of branches; polyps retractile into more or less well-developed calyces; spicules not scaly."

REMARKS: To the above diagnosis, taken from Kinoshita (1910), I would add: central chord of axis chambered; spicules of outer rind as thick spindles, irregularly tuberculate, or thick plates; in the anthocodiae, small bifurcate spicules shaped like crutches.

Genus KEROEIDES Studer

Keroeides Studer, 1887, Arch. Naturgesch., 53 Jahrg. Bd. 1: 30. Wright and Studer, 1889, Challenger Zool. 31 (1); 168. Kinoshita, 1910, Annot. Zool. Japon. 8 (4): 225. Stiasny, 1937, Siboga Exped. Monog. 13b[8]: 113.

This genus is easily recognized by its spiculiferous "scleraxonian" axis which, however, is penetrated by a chambered central chord.

Keroeides so perfectly bridges the gap between Scleraxonia and Holaxonia that its placement in the present system is difficult. For the sake of convenience, I am treating it in the same part of this report along with the scleraxonians. Its chambered axial chord points conclusively to its holaxonian affinities, and Kinoshita was unquestionably correct when he stated that *Keroeides* is no scleraxonian.

TYPE SPECIES: *Keroeides koreni* Wright and Studer, by subsequent monotypy, the first species being assigned by Wright and Studer, 1889.

The species known from, or likely to be found in, Hawaiian waters may be separated by the following key.

1. Superficial spicules as closely set large plates like paving stones . . . . . **mosaica** sp. nov.
1. Superficial spicules as smaller spindles or elongate plates 2
2. Colonies unbranched or very sparingly branched . . . . . **fallax** sp. nov.
2. Colonies profusely branched in one plane 3
3. Calyces small, usually 1 mm. or less in width at the base and 0.5–0.75 mm. in height, blunt conical; branches slender, end-twigs about 0.5 mm. in diameter; superficial spicules all rather large, pointed spindles. Bright red . . . . . **koreni** Wright and Studer
3. Calyces larger, often 2.5 mm. in width at the base and 1.5–2.0 mm. in height, cylindrical or very slightly tapered; branches robust, end-twigs 1.0–1.5 mm. in diameter; superficial spicules large spindles interspersed with smaller, slender spindles. White or yellowish . . . . . **pallida** Hiles

Keroeides mosaica sp. nov.

Fig. 10*a–f*

DIAGNOSIS: Rind with large, closely fitting, polygonal, pavement-like plates. Twigs stiff;

branching lateral. Tentacular crutches 0.06–0.08 mm. long. White.

DESCRIPTION: The branching is lateral and apparently in one plane but the type is too fragmentary to demonstrate the overall pattern. The branches are rather stiff, bending upward, about 2 mm. in diameter and not noticeably tapering. The polyps are arranged in single rows bilaterally along the branches, either alternate or opposite; an occasional individual faces more toward one side or the other. The calyces are low and dome-like, the younger ones scarcely projecting above the general surface of the rind. The anthocodiae are fully retractile within the calyces.

The spicules of the outer rind are large, rounded or polygonal plates up to 3 mm. in length and 1.5 mm. in width, closely fitted as in mosaic. The plates near the verrucal margin become more elongate and merge into the warted spindles of the anthocodiae. In the tentacles there are small spinose rods, and crutch-shaped spicules 0.06–0.08 mm. long; the gullet has small spindles. The major sclerites are milky white, the smaller forms quite clear and colorless. The axis is made up of smooth, terete spindles closely bound together by a horny matrix; there is a chambered central chord. The axis is light brown in color, due to the horny material.

HOLOTYPE: U.S.N.M. No. 49336. Off Molokai: Lae-o Ka Laau Light bearing North 74° 30′ West, 8.1 miles distant; depth 92–212 fathoms; fine gray-brown sand; bottom temperature 67° F. (reading probably made in shallow water at beginning of drag); "Albatross" station 3838, April 4, 1902.

REMARKS: This very distinct species bears a strong superficial resemblance to certain of the species of the holaxonian genus *Paracis*, but its spicular axis immediately distinguishes it.

Keroeides fallax sp. nov.
Fig. 11*a–d*

Muricella tenera Nutting, 1908, U. S. Natl. Mus., Proc. 34: 586.

Nec *Muricella tenera* Ridley, 1884, Zool. Coll. H.M.S. "Alert": 335.

DIAGNOSIS: Sparingly branched: simple or once-forked. Calyces tall. Outer rind with thick spindles. Tentacular crutches 0.15–0.17 mm. long. Color, cream white (alcohol).

DESCRIPTION: The colonies are ordinarily only once bifurcate and often are simple, arising from a disk-like base attached to stones or shells. The stem is about 2.5 mm. in diameter and tapers to 1.0 mm. in the smallest part of the twigs. The polyps are set in the biserial arrangement typical of the genus, with an occasional individual out of line as is usual in the other species. They are well separated, often 10 mm. or more apart; the calyces are tall and nearly cylindrical, slightly tapered distally, about 2 mm. in diameter at the base and 1.5 mm. high. The anthocodiae usually remain exsert, though the tentacles are folded tightly inward.

The spicules of the rind are large, blunt, somewhat flattened spindles densely packed together. Spindles of the verrucae smaller, longitudinally arranged, merging with the spicules of the anthocodial wall, which are spinose rods. In the tentacles are curved rods and "crutches," the latter being much larger than those of *K. mosaica*, reaching a length of 0.17 mm. The spicules of the axis are smooth, terete spindles, occasionally fused together, set in a horny matrix. In the walls of the long gullet there are many sharply pointed spinose spindles of small size.

In alcohol, the colonies are creamy white; the axis is light brown.

HOLOTYPE: U.S.N.M. No. 49337. South coast of Molokai: Mokuhooniki Islet bearing North 46°45′ East, 12 miles distant; depth 134–130 fathoms; sand, shell, and rock; bottom temperature 69.7° F.; "Albatross" station 3854, April 9, 1902.

RECORD: Off Molokai: Lae-o Ka Laau Light bearing North 74°30′ West, 8.1 miles distant; depth 92–212 fathoms; fine gray-

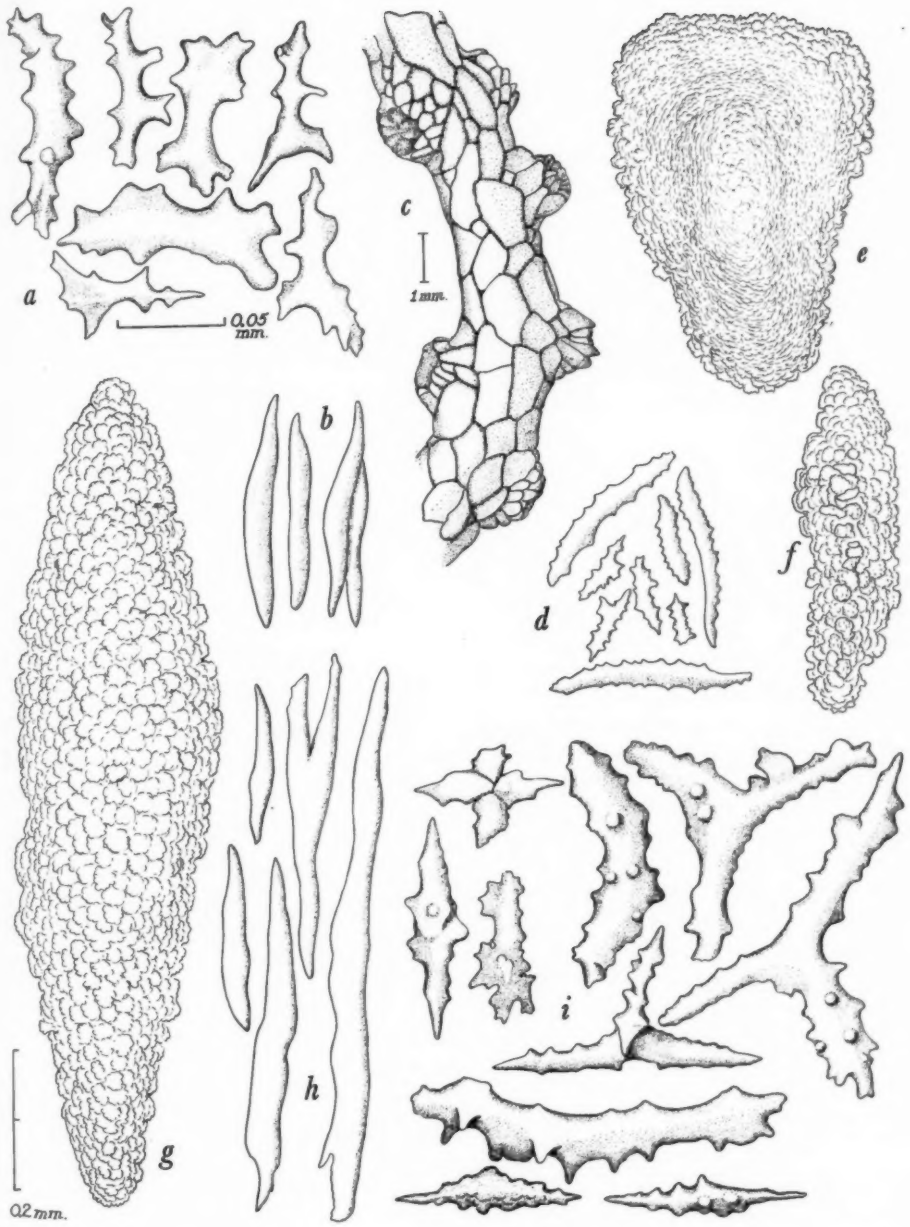

FIG. 10. *a–f, Keroeides mosaica* sp. nov.: *a*, Spicules of tentacles; *b*, spindles of axis; *c*, part of branch; *d*, flat rods from tentacles; *e–f*, smaller plates from rind. *g–i, Keroeides pallida* Hiles: Spicules of cortex surface (*g*), axis (*b*), anthocodia (*i*), including tentacular crutches. Scale at *a* applies to *a* and *i*; *c*, to *c* only; *g*, to all others.

brown sand; bottom temperature 67° F. (probably at shallow end of drag); "Albatross" station 3838, April 4, 1902.

Keroeides koreni Wright and Studer
Fig. 11*e–g*

Keroeides koreni Wright and Studer, 1889, Challenger Zool. 31 (1): 169, pl. 40, fig. 3. Kinoshita, 1910, Annot. Zool. Japon. 8 (4): 225. Bayer, 1949, Pacific Sci. 3 (3): 198. pl. 3, fig. 3.

DIAGNOSIS: Profusely branched in one plane, flabellate. Calyces small, subconical, projecting. Rind with blunt spindles, sometimes bent. Tentacular crutches up to 0.1 mm. long, often with several branches at one end. Red.

DESCRIPTION: The colonies are richly branched in one plane, rarely anastomosing or not at all; flabellate. The twigs are slender, about 0.5 mm. in diameter. The calyces are small, 1.0 mm. or less in diameter at the base and 0.5–0.75 mm. in height, subconical, and arranged in the usual biserial fashion.

The rind spicules are large, more or less flattened spindles often blunt and oval in outline. The tentacles have spiny rods, often curved, and the usual crutch- or Y-shaped spicules. The crutches measure 0.07–0.1 mm. in length. The gullet contains small, pointed spindles with rude sculpture. The spicules of the axis are long, occasionally fused together, quite smooth and terete.

The colony in alcohol is bright red.

REMARKS: Although *Keroeides koreni* is known from the Marshall Islands it has not yet been reported from the Hawaiian Islands, but it may well occur there.

Keroeides pallida Hiles
Fig. 10*g–i*

Keroeides pallida Hiles, 1899, Willey's Zool. Res. 2: 201, pl. 22, figs. 12–16.

Keroeides gracilis Nutting, 1908, U. S. Natl. Mus., Proc. 34: 569.

Nec *Keroeides gracilis* Whitelegge, 1897, Austral. Mus., Mem. 3: 308, pl. 16, figs. 1–5.

Paramuricea aequatorialis Nutting, 1908, U. S. Natl. Mus., Proc. 34: 580.

Nec *Paramuricea aequatorialis* Wright and Studer, 1889, Challenger Zool. 31 (1): 100, pl. 22, fig. 6; pl. 26, fig. 3.

Clematissa verrilli Nutting, 1908, U. S. Natl. Mus., Proc. 34: 584.

Nec *Clematissa verrilli* Wright and Studer, 1889, Challenger Zool. 31 (1): 107, pl. 22, fig. 10; pl. 26, fig. 6.

DIAGNOSIS: Colonies branched in one plane, flabellate. Calyces large and conspicuous. Rind with large spindles between which are many small spindles. Tentacular crutches 0.12–0.17 mm. long. Color, cream white.

DESCRIPTION: The robust colonies are branched in one plane and assume a flabellate form; the branches are rather stout, the end twigs measuring 1.0–1.5 mm. in diameter. The calyces are large, 2.0–2.5 mm. wide at the base and 1.5–2.0 mm. tall, cylindrical or slightly tapered, biserially arranged. The anthocodiae are usually withdrawn almost completely in preservation.

The spicules of the rind are large, blunt spindles with many smaller spindles filling up the spaces between them. The large spindles do not fit closely together as they do in *K. fallax*. The spindles of the calyces are obliquely oriented at the base, longitudinally toward the apex. The calycular spicules merge into the anthocodial armature, which consists of thorny rods set *en chevron* in the tentacle bases. In the tentacles there are also some large, Y-shaped crutches about 0.12–0.17 mm. long, which have a different shape from those of *K. fallax*. The spicules of the axis are smooth, rather crooked spindles, which often anastomose and fuse together.

RECORDS: South coast of Molokai: Mokuhooniki Islet bearing North 49°45′ East, 12.6 miles distant; depth 115–134 fathoms; coarse sand and shell; bottom temperature 68.5° F.; "Albatross" station 3853, April 9, 1902.

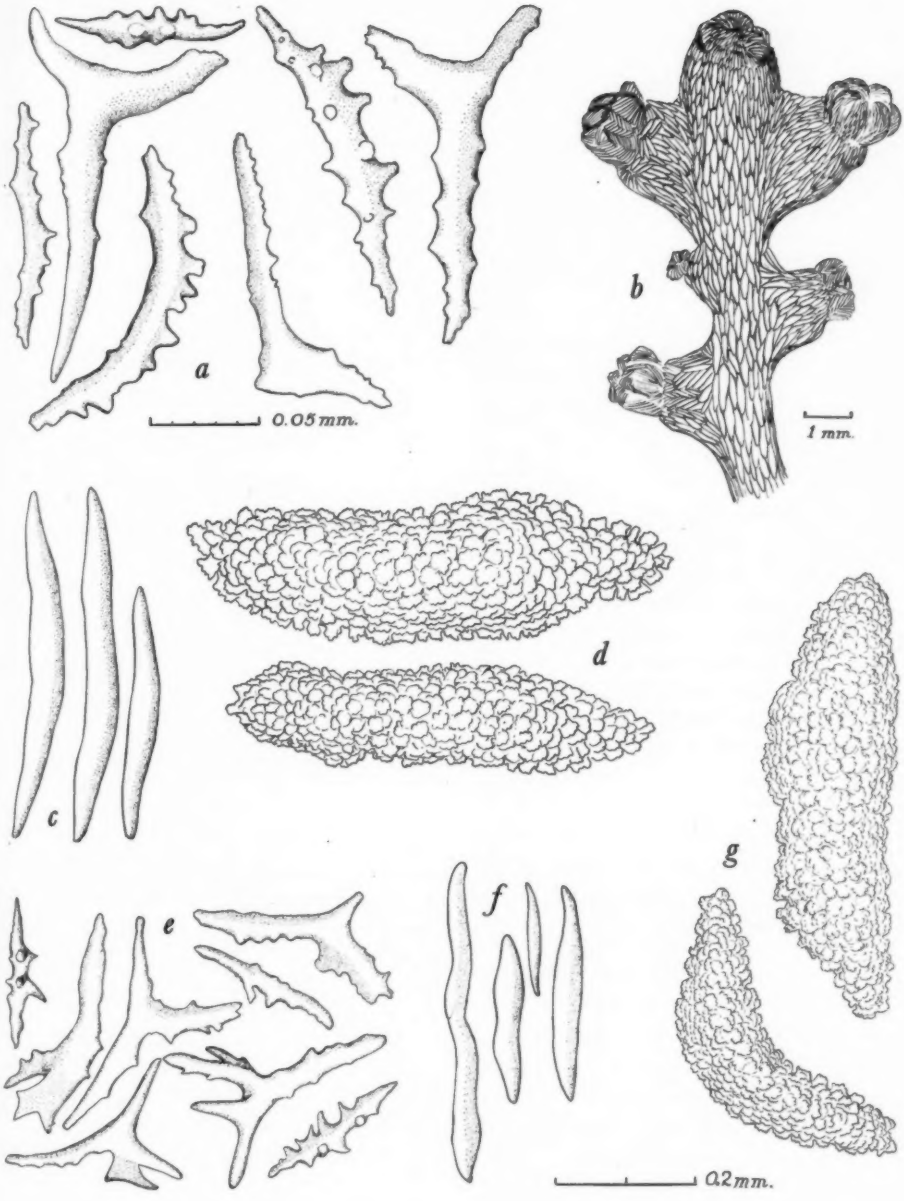

FIG. 11. *a–d*, *Keroeides fallax* sp. nov.: *a*, Tentacular crutches; *b*, branch tip; *c*, axial spicules; *d*, spindles of cortex. *e–g*, *Keroeides koreni* Wright and Studer: *e*, Tentacular crutches and pharyngeal rods; *f*, axial spindles; *g*, cortical spindles. Scale at *b* applies only to *b*; scale at *a* to *a* and *e*; scale at *g* to all others.

Pailolo Channel: Mokuhooniki Islet bearing North 18° East, 5.6 miles distant; depth 138–140 fathoms; fine sand and mud; bottom temperature 60.2°–60.5° F.; "Albatross" station 3859, April 9, 1902.

REMARKS: *Keroeides pallida* may be distinguished from *K. fallax* by its more profuse branching and coarser habit, by the small spindles clearly visible between the large sclerites, and by the form of its tentacular crutches.

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A Translation of the Keys in the *Flora Micronesica* (1933) of Ryozo Kanehira

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THE STANDARD BOOK on the botany of Micronesia is R. Kanehira's *Flora Micronesica* (1933). This was based on much new field work, careful study, and is a complete and profusely illustrated flora. Its usefulness to most botanists, however, is limited by the fact that it is printed wholly in Japanese characters. The writer has slowly and laboriously translated into English Kanehira's keys, all of which lead from the genera down to the species. It is a free translation, as a literal one would in places be unintelligible. In a few instances Kanehira's phrases are given in quotation marks and the translator's preferred version is given after it in brackets. Though inconsistent, the capitalization and spelling of the specific epithets follows that used by Kanehira (except for *Gymnosporia palanica*). Unfortunately it has been impossible to ask the collaboration of Kanehira, as he died in 1948.

The following translation is offered to the botanical public with confidence that it will supply a genuine need.

Page 59 PANDANUS

(1)1. Fruit borne in clusters . . . . . (2)
2. Fruit borne singly . . . . . (4)
(2)1. Fruit ellipsoid, less than 6 cm. in diameter . . . . . (3)
2. Fruit globose, more than 8 cm. in diameter . . . . . **P. Kanehirae**
(3)1. Fruit [cluster] flame-shaped, wrapped in leaf sheath [bracts]; small fruit [phalange] not conspicuously angled . . . . . **P. aimiriikensis**
2. Fruit "spiral" [or cone- or shell-shaped], attached in a cluster, not enclosed in bracts; phalange with conspicuous angles . . . . . **P. macrojeanneretia**
(4)1. Phalange with one seed . . . . . (5)
2. Phalange many seeded . . . . . (6)
(5)1. Fruit globose, the diameter 30 cm. . . . . **P. dubius**
2. Fruit ellipsoid, scarlet when ripe, the diameter 13 cm. . . . . **P. patina**
(6)1. Phalange with summit jagged, the tips sharp pointed . . . . . **P. duriocarpus**
2. Phalange with summit jagged, the tips not sharp pointed . . . . . (7)
(7)1. Phalange obconic, having 2–4 seeds, the summit not conspicuously jagged . . . . . **P. kafu**
2. Phalanges numerous, 8–11-seeded, obovoid, the summit jagged . . . . . **P. sinensis**

Page 88 FICUS

(1)1. Flowers hidden in bottom of fruit by stipule-like scales . . . . . (2)
2. Flowers hidden in bottom of fruit but without stipule-like scales . . . . . (3)

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Manuscript received May 31, 1955.

(2)1. Leaves long elliptic . . . **F. carolinensis**
2. Leaves elliptic, the apex emarginate . . . . . **F. retusa**
(3)1. Leaves cordate at base . . . . . (4)
2. Leaves not cordate at base . . . . . (5)
(4)1. Creeping vine; leaf venation pinnate, not palmately 3-veined from the base . . . . . **F. ramentacea**
2. Tall tree; leaves pinnately veined but at base palmately 3-veined . . . . . **F. Senfftiana**
(5)1. Leaves ovate, at base rounded but asymmetric . . . . . **F. tinctoria**
2. Leaves broadly or narrowly elliptic . . . . . **F. philippinensis**

Page 93 LAPORTEA

(1)1. Leaves elongate perfect elliptic, 30 cm. long . . . . . **L. kusaiana**
2. Leaves ovate, 18 cm. long . . . . . **L. saipanensis**

Page 97 LORANTHUS

(1)1. Leaves broad elliptic, gradually pointed, hairy, 12 cm. long . . **L. caudatifolius**
2. Leaves from oblong to ovate, 8 cm. long . . . . . **L. ponapensis**

Page 98 PISONIA

(1)1. Leaf obovate or long elliptic; inflorescence glabrous; fruit linear, 6 cm. long, slippery, even . . . . . **P. umbellifera**
2. Leaf ovate; inflorescence brown pubescent; fruit 1–1.5 cm. long, lunate, with the outer surface prickly . . . . . **P. grandis**

Page 109 HORSFIELDIA

(1)1. Leaves chartaceous, lance-oblong, more than 25–30 cm. long; fruit globose . (2)
2. Leaves coriaceous, oblong-lanceolate, 18 cm. long; fruit ellipsoid . . . . . **H. palauensis**
(2)1. Fruit 1.5–1.8 cm. in diameter . **H. nunu**
2. Fruit 3–3.5 cm. in diameter . . . . . **H. amklaal**

Page 117 CINNAMOMUM

(1)1. Leaves having petioles . . . . . (2)
2. Leaves sessile . . . . . **C. sessilifolium**
(2)1. Leaves ovate, the apex acuminate . . . . . **C. carolinense**
2. Leaves long elliptic-ovate, acute . . . . . **C. carolinense** var. **oblongum**

Page 124 PITTOSPORUM

(1)1. Leaves "oblong" [=lanceolate], 16 cm. long; flowers 11 mm. long; ovary hairy . . . . . **P. ponapense**
2. Leaves lanceolate, 10 cm. long; flowers 8 mm. long; ovary glabrous . . . . . **P. kusaiense**

Page 127 PARINARIUM

(1)1. Leaves long elliptic, 10–15 cm. long; fruit 5–10 cm. in diameter . . . . . **P. glaberrimum**
2. Leaves ovate or elongate ovate, 8–11 cm. long; fruit 1.5 cm. in diameter . . . . . **P. palauense**

Page 133 CYNOMETRA

(1)1. Leaflets 5–8 cm. long; petals 7 mm. long; outer surface of fruit wrinkled . . . . . **C. carolinensis**
2. Leaflets as much as 11 cm. in length; petals 11 mm. long; surface of fruit not wrinkled . . . . . **C. Yokotai**

Page 148 SERIANTHES

(1)1. Leaflets 12 mm. long, 5 mm. wide; corolla tube 2 cm. long; pod 15 cm. long, 5 cm. wide . . . . . **S. grandiflora**
2. Leaflets 5 mm. long, 2 mm. wide; corolla tube 12 cm. long; pod 12 cm. long, 2.5 cm. wide . . . . . **S. Nelsonii**

Page 151 EVODIA

(1)1. Leaflets less than 7–9 cm. long . . . . . **E. nitida**
2. Leaflets more than 10 cm. long . . . (2)
(2)1. Flowers 6 mm. long; calyx lobes 1.5 mm. long . . . . . **E. palawensis**

2. Flowers 1.5 cm. long; calyx lobes 7 mm. long . . . . . **E. trichantha**

Page 161 AGLAIA

(1)1. Shrubs; leaflets elongate obovate-elliptic, 2.5 cm. long; lateral veins 16 on a side . . . . . **A. palauensis**
2. Small trees; leaflets lance-oblong or broadly lanceolate, less than 20 cm. long; lateral veins 13 or less on a side . . . . . (2)
(2)1. Leaf elliptic; branches of inflorescence many; calyx lobes acute; fruit elliptic-orbicular . . . . . **A. mariannensis**
2. Leaf lance-oblong or broadly lanceolate; branches of inflorescence few; calyx lobes obtuse; fruit long obovoid . . . . . **A. ponapensis**

Page 170 CLEISTANTHUS

(1)1. Leaves 6–13 cm. long; fruiting capsule 8–15 mm. long . . . . . (2)
2. Leaves 15–22 cm. long; fruiting capsule 5 mm. long . . . . . **C. Morii**
(2)1. Lower surface of leaf brown; edges of the capsule rounded . . **C. carolinensis**
2. Lower surface of leaf grayish white; edges of capsule ridged . **C. angularis**

Page 177 MACARANGA

(1)1. Leaves chartaceous, "ovate" [=round], 20 cm. long . . . . . **M. carolinensis**
2. Leaves coriaceous, round, 30 cm. long . . . . . **M. Thompsonii**

Page 182 BUCHANANIA

(1)1. Leaves elongate obovate, 10–15 cm. long, 6–8 cm. wide; fruit 1 cm. in diameter . . . . . **B. palawensis**
2. Leaves broadly obovate, 15–22 cm. long, 7–12 cm. wide; fruit 1.5 cm. in diameter . . . . . **B. Engleriana**

Page 187 SEMECARPUS

(1)1. Leaves oblanceolate, 100 cm. long; fruit reniform, 3 cm. long . . . . . **S. Kraemeri**
2. Leaves "lanceolate" [=narrowly oblanceolate], 40 cm. long; fruit globose, 2 cm. long . . . . . **S. venenosa**

Page 192 GYMNOSPORIA

(1)1. Leaves broad ovate, the apex rounded . . . . . **G. palauica**
2. Leaves ovate, the apex subobtuse . . . . . **G. Thompsonii**

Page 201 ALLOPHYLUS

(1)1. Small trees; leaflets elliptic, less than 4.5 cm. wide, the margin entire . . . . . **A. holophyllus**
2. Shrubs, trees, or vines; leaflets ovate, more than 6 cm. wide, the margins coarsely serrate . . . . . (2)
(2)1. Spike longer than the leaves, few branched . . . . . **A. ternatus**
2. Spike shorter than the leaves, many branched . . . . . **A. timorensis**

Page 209 ELAEOCARPUS

(1)1. Leaves ovate or elliptic . . . . . (2)
2. Leaves lanceolate . . . . . (3)
(2)1. Leaves obovate or elliptic; fruit elliptic, more than 3 cm. in length . . . . (4)
2. Leaves ovate; fruit less than 1.5 cm. in length . . . . . (5)
(3)1. Fruit elliptic, 2.5 cm. long . . . . . **E. carolinensis**
2. Fruit globose, 1.5 cm. long . . **E. joga**
(4)1. Leaf base obtuse; fruit 4.5 cm. long . . . . . **E. kusaiensis**
2. Leaf base acute; fruit 3 cm. long . . . . . **E. rubidus**
(5)1. Leaves elliptic, 6–8 cm. long . . . . . **E. Kerstingianus**
2. Leaves ovate, 10–13 cm. long . . . . . **E. Kusanoi**

Page 219 TRICHOSPERMUM

(1)1. Branchlets stellate pubescent; leaves long ovate, 15 cm. long, lateral veins 6–7 on a side; flowers 2 cm. in diameter . . . . . **T. Ikutai**

2. Branchlets glabrous; leaves long elliptic, 10 cm. long, lateral veins 4–5 on a side; flowers 1 cm. in diameter..... **T. Ledermannii**

Page 228 HERITIERA

(1)1. Leaves long elliptic; petioles 2 cm. long; fruit skin thin.... **H. littoralis**
2. Leaves water-chestnut-shaped; petioles 4–6 cm. long; fruit skin thick..... **H. longipetiolata**

Page 233 CALOPHYLLUM

(1)1. Leaves 6–7 cm. long; fruit ellipsoid, 6–7 mm. long..... **C. cholobtaches**
2. Leaves 10–15 cm. long; fruit globose, 3 cm. in diameter.... **C. Inophyllum**

Page 235 GARCINIA

(1)1. Fruit globose, 3–4 cm. in diameter... **G. Matudai**
2. Fruit obovoid or long ellipsoid, less than 2 cm. in diameter..... (2)
(2)1. Fruit long obovoid, 2 cm. in diameter, 3 cm. long..... **G. rumiyo**
2. Fruit ellipsoid, 2 cm. long..... (3)
(3)1. Leaves 7–8 cm. long, almost sessile.. **G. ponapensis**
2. Leaves 12 cm. long; petioles 10–12 mm. long..... **G. trukensis**

Page 241 PENTAPHALANGIUM

(1)1. Leaves 20 cm. long; flowers 20 mm. in diameter; fruit 2 cm. long..... **P. carolinense**
2. Leaves 15 cm. long; flowers 10 mm. in diameter; fruit 5 cm. long..... **P. Volkensii**

Page 248 THYMELAEACEAE

(1)1. Leaves 15–20 cm. long, 7–8 cm. wide; corolla tube white, 15 mm. long..... **Phaleria Cumingii**
2. Leaves 12–17 cm. long, 5–6 cm. wide; corolla tube golden yellow, 24 mm. long..... **Wikstroemia elliptica**

Page 252 BARRINGTONIA

(1)1. Leaves obovate or long elliptic, 40 cm. long, 15–20 cm. wide; fruit 4-angled, the 4 sides of the body 10 cm. long..... **B. asiatica**
2. Leaves long elliptic or oblanceolate, 30 cm. long, as much as 6–10 cm. wide; fruit long ellipsoid, 5–6 cm. long..... **B. racemosa**

Page 257 RHIZOPHORA

(1)1. Leaves "lance-oblong" [=narrowly elliptic]; flowers twinned, sessile [on the peduncle]..... **R. apiculata**
2. Leaves elliptic; flowers mostly pedicelled in short cymes.. **R. mucronata**

Page 262 TERMINALIA

(1)1. Leaves long elliptic-obovate, as much as 50 cm. long; fruit ellipsoid, acute at both ends..... **T. carolinensis**
2. Leaves obovate, 30 cm. long; fruit ellipsoid, flattened..... **T. Catappa**

Page 265 DECASPERMUM

(1)1. Leaves glabrous, oblong..... **D. fruticosum**
2. Branchlets, petioles, and midrib of sepals silvery white hairy; leaves lanceolate..... **D. Raymundi**

Page 267 EUGENIA

(1)1. Leaf base cordate..... (2)
2. Leaf base not cordate..... (6)
(2)1. Leaf ovate..... (3)
2. Leaf long elliptic..... (4)
(3)1. Flowers in terminal corymbs..... **E. Suzukii**
2. Flowers in axillary cymes **E. javanica**
(4)1. Leaves 15–30 cm. long..... (5)
2. Leaves 8–14 cm. long..... **E. Thompsonii**
(5)1. Small twigs 4-angled and -winged... **E. stelechanthoides**
2. Small twigs terete, wingless..... **E. stelechantha**

(6)1. Leaves less than 8 cm. long . . . . . (7)
2. Leaves more than 10 cm. long . . . . (8)
(7)1. Leaves long elliptic, acute at both ends . . . . . **E. palumbis**
2. Leaves elliptic or obovate . . . . . (9)
(8)1. Leaves more than 15 cm. long . . . . . **E. malaccensis**
2. Leaves less than 12 cm. long . . . (10)
(9)1. Leaves elliptic; flowers mostly single in the axils . . . . . **E. Reinwardtiana**
2. Leaves obovate, obtuse; flowers in terminal cymes . . . . . **E. palauensis**
(10)1. Leaves pinnately veined . . . . . **E. carolinensis**
2. Leaves parallel veined . . . . . **E. cumini**

Page 278 ASTRONIA

(1)1. Leaves long elliptic; inflorescence pendent . . . . . **A. ponapensis**
2. Leaves elliptic; inflorescence erect. (2)
(2)1. Leaf tip rounded [apiculate]; inflorescence a panicle; petals milky white . . . . . **A. palauensis**
2. Leaf tip acuminate; inflorescence a cyme; petals yellow . . **A. carolinensis**

Page 282 MEDINILLA

(1)1. Vine; leaves long elliptic . . . . . **M. Blumeana**
2. Small shrub; leaves large, ovate, size irregular . . . . . **M. diversifolia**

Page 292 POLYSCIAS

(1)1. Leaflets entire; inflorescence a panicle; fruit flat, round . . . . . **P. grandifolia**
2. Leaflets pubescent, coarsely serrate; inflorescence of compound cymes; fruit ovoid . . . . . **P. subcapitata**

Page 294 SCHEFFLERA

(1)1. Small trees; flowers erect, in "spikes" [=racemose umbellets]. **S. pachyclada**
2. Vines; flowers in cymes . . . **S. odorata**

Page 298 DISCOCALYX

(1)1. Leaves 25–35 cm. long. **D. ponapensis**
2. Leaves 15–25 cm. long. **D. megacarpa**

Page 299 MAESA

(1)1. Leaves round or elliptic . . . . . **M. palauensis**
2. Leaves obovate . . . . . **M. carolinensis**

Page 300 RAPANEA

(1)1. Leaves 5–11 cm. long . . . . . **R. carolinensis**
2. Leaves 12–16 cm. long. **R. palauensis**

Page 307 SIDEROXYLON

(1)1. Leaves 8–12 cm. long; seed 1 . . . . . **S. glomeratum**
2. Leaves 15–21 cm. long; seeds 2–3 . . . . . **S. micronesicum**

Page 313 COUTHOVIA

(1)1. Leaves broad ovate, the base obtuse; lateral veins 6 to a side; fruit fusiform . . . . . **C. calophylla**
2. Leaves obovate, the base cuneate; lateral veins 9 to a side; fruit ellipsoid . . . . . **C. toua**

Page 316 FAGRAEA

(1)1. Fruit ellipsoid . . . . . **F. ksid**
2. Fruit globose . . . . . (2)
(2)1. Leaves elliptic, obtuse, petioled . . . . . **F. sair**
2. Leaves obovate, obtuse, subsessile . . . . . **F. galilai**

Page 319 GENIOSTOMA

(1)1. Leaves sessile . . . . . **G. sessile**
2. Leaves petioled . . . . . (2)
(2)1. Ultimate branches of inflorescence densely pubescent . . . . . (3)
2. Ultimate branches of inflorescence glabrous . . . . . (4)
(3)1. Leaves 4–6 cm. long; calyx lobes acute, 3-angled . . . . . **G. Hoeferi**
2. Leaves 6–8 cm. long; calyx lobes obtuse, 3-angled . . . . . **G. micranthum**
(4)1. Leaves long ovate, acute. **G. kusaiense**
2. Leaves lanceolate, subacuminate . . . . . **G. stenurum**

Page 325 Alyxia

(1)1. Leaves opposite, 4.5 cm. long; fruit 10 mm. long, 6 mm. in diameter . . . . . **A. palauensis**
2. Leaves whorled, 4–6 cm. long; fruit 13 mm. long, 8 mm. in diameter . . . . . **A. Torresiana**

Page 327 Cerbera

(1)1. Inflorescence a corymb; corolla scarlet, 1.5 cm. in diameter . . . . **C. floribunda**
2. Inflorescence a cyme; corolla white, 3 cm. in diameter . . . . . (2)
(2)1. Calyx lobes long elliptic; corolla lobes asymmetric, 3-angled . . . . . **C. dilatata**
2. Calyx lobes shallow; corolla lobes obovate . . . . . **C. Manghas**

Page 332 Rauwolfia

(1)1. Leaves elliptic; inflorescence longer than the leaves; flowers few . . . . . **R. laxiflora**
2. Leaves lanceolate; inflorescence short; flowers many . . . . . **R. insularis**

Page 341 Gmelina

(1)1. Scandent shrub; leaves elliptic, 10 cm. long . . . . . **G. elliptica**
2. Tall trees; leaves obovate or broad elliptic, 10–15 cm. long . . . . . **G. palawensis**

Page 342 Premna

(1)1. Small shrub; leaves cordate, 8–12 cm. long . . . . . **P. angustiflora**
2. Small tree; leaves elliptic, 10–12 cm. long . . . . . **P. gaudichaudii**

Page 343 Vitex

(1)1. Shrubs . . . . . **V. trifolia**
2. Tall trees . . . . . (2)
(2)1. Leaves simple . . . . . **V. cofassus**
2. Leaves of 5 leaflets . . . . . **V. glabrata**

Page 348 Cyrtandra

(1)1. Vines . . . . . **C. palawensis**
2. Small shrubs . . . . . (2)
(2)1. Leaves long elliptic; petiole 7 cm. long; calyx lobes two, 3-angled . . . . . **C. tôdaiensis**
2. Leaves ovate or rhombic-elliptic; petiole less than 5 cm. long; calyx lobes 4, lanceolate . . . . . (3)
(3)1. Leaves rhombic; calyx lobes 11 mm. long, the outer surface pubescent . . . . . **C. ponapensis**
2. Leaves ovate-elliptic; calyx obes 18 mm. long, glabrous . . . . . **C. Urvillei**

Page 354 Bikkia

(1)1. Corolla lobes acute, as long as broad; calyx lobes linear . . . . . **B. palauensis**
2. Corolla lobes obtuse, shorter than wide; calyx lobes with three pointed prongs . . . . . **B. mariannensis**

Page 360 Ixora

(1)1. Flowers 2–3, terminal . . . . . **I. triantha**
2. Inflorescence umbellate, ball-like, or a compact tassel . . . . . (2)
(2)1. Inflorescence ball-like, usually compact . . . . . **I. confertiflora**
2. Inflorescence an umbel, usually elongate . . . . . (3)
(3)1. Leaves long elliptic, as much as 25 cm. in length . . . . . **I. pulcherrima**
2. Leaves lanceolate, 11 cm. long . . . . . **I. pulcherrima** var. **lanceolata**

Page 364 Morinda

(1)1. Vines . . . . . (2)
2. Small trees . . . . . (3)
(2)1. Large vines; leaves ovate, 7–9 cm. long . . . . . **M. glandulosa**
2. Small vines; leaves long elliptic-ovate, 10–13 cm. long . . . . . **M. volubilis**
(3)1. Flower head with enlarged petals if any . . . . . **M. latibracteata**
2. Flower head without enlarged petals . . . . . (4)
(4)1. Leaves long elliptic, 15–20 cm. long; flower head an elongate cluster . . . . . **M. pedunculata**

2. Leaves broad elliptic, 15–25 cm. long or more; flower head for the most part in a short cluster . . . . . **M. citrifolia**

Page 370 PSYCHOTRIA

(1)1. Flowers terminal, in a long panicle; leaves more than 18 cm. long . . . . . **P. rhombocarpa**
2. Flowers in a short terminal cyme or cluster; leaves less than 15 cm. long . . . . . (2)
(2)1. Flowers clustered . . . . . **P. Merrillii**
2. Flowers in a short cyme . . . . . (3)
(3)1. Leaves long elliptic, acute at both ends . . . . . **P. arbuscula**
2. Leaves obovate, the apex obtuse . . (4)
(4)1. Leaves coriaceous; lateral veins 6–8 on a side; corolla 6 mm. long . **P. mariana**
2. Leaves membranous; lateral veins 5 on a side; corolla 2.5 mm. long . . . . . **P. rotensis**

Page 379 TARENNA

(1)1. Leaves 7–10 cm. long; corolla tube 3 mm. long, the lobes long elliptic . . . . . **T. glabra**
2. Leaves 12–16 cm. long; corolla tube 6 mm. long, the lobes obovate . . . . . **T. sambucina**

Page 381 TIMONIUS

(1)1. Leaf base auriculate or cordate . . . . (2)
2. Leaf base not auriculate or cordate . (3)
(2)1. Upper side of leaves pubescent . . . . . **T. mollis**
2. Upper side of leaves smooth and glabrous . . . . . (4)
(3)1. Leaves with lower surface pubescent along midrib and lateral veins . . . . . **T. ponapensis**
2. Leaves glabrous or slightly pubescent . . . . . (5)
(4)1. Leaves rhombic or elliptic . . . . . **T. corymbosus**
2. Leaves ovate or elliptic . **T. subauritus**
(5)1. Leaves long elliptic, 12–16 cm. long . . . . . **T. Ledermannii**
2. Leaves elliptic or obovate, 13 cm. long . . . . . (6)
(6)1. Fruit long, slender, commonly 6 mm. in diameter . . . . . **T. korrense**
2. Fruit short, commonly 10 mm. in diameter . . . . . **T. albus**

A Report on the Poisonous Fishes Captured During the Woodrow G. Krieger Expedition to Cocos Island[1]

BRUCE W. HALSTEAD AND DONALD W. SCHALL[2]

THIS IS THE FOURTH of a series of epidemiological reports concerning the poisonous fishes of the tropical Pacific. The first report (Halstead and Bunker, 1954*a*) dealt with the Phoenix Islands, the second (Halstead and Bunker, 1954*b*) with Johnston Island, and the third (Halstead and Schall, 1955) with the Galápagos Islands. For a general résumé of the overall problem of poisonous fishes and ichthyosarcotoxism, the reader is referred to two earlier reports by the senior author (1951, 1953).

A more complete discussion of the manner in which fishes are believed to become poisonous has been published elsewhere (Halstead and Bunker, 1954*a*). There are probably a multiplicity of factors governing the degree of toxicity of a fish, viz., abundance of certain types of food, the availability of certain types of organic chemical constituents in that food, and the physiology of the fish.

Although numerous poisonous fish species are known to occur in the West Indies, Red Sea, and in various parts of the Pacific, a literature of more than 1500 publications on poisonous marine organisms is silent regarding the tropical Eastern Pacific. The basic objective of this expedition was to determine if poisonous fishes occurred in this region, with the hope that the knowledge gained thereby would contribute directly to a better understanding of the origin and distribution of toxic fishes in the tropical Pacific. As there are no inhabitants at Cocos, it was not possible to appraise the practical importance of the poisonous fishes found.

The expedition to Cocos Island was made possible through the generosity of Mr. Woodrow G. Krieger, president of the Douglas Oil Company of California, and the Office of Naval Research, Department of the Navy. In addition to making his 96-foot yacht, the "Observer," available to the scientific party, Mr. Krieger also installed special laboratory and refrigeration facilities on his yacht to accomodate our group. Grateful acknowledgement is made for the invaluable contributions to our research program of both Mr. Krieger and the Office of Naval Research. With the exception of the family Scaridae, all of the fishes listed in this report were identified by Dr. Boyd Walker of the Department of Zoology, University of California at Los Angeles. Dr. Leonard P. Schultz of the U. S. National Museum identified the scarids. Our sincere appreciation is expressed to these individuals for their valuable contributions to this report. The scientific party included Norman C. Bunker, Jeanne M. Bunker, Leonard S. Kuninobu, Donald G. Ollis, and the senior author. The "Observer" departed from Newport Bay, California, on December 3, 1952,

[1] This investigation was supported by a research grant from the Division of Research Grants and Fellowships, National Institutes of Health, Public Health Service, and a contract from the Office of Naval Research, Department of the Navy (Contract No. NONR-205). Manuscript received January 14, 1955.

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and proceeded to Punta Arenas, Costa Rica, and thence to Cocos Island.

GEOGRAPHY AND ECOLOGY OF COCOS ISLAND

Cocos Island is located at lat. 5°22′N., long. 87°04′W., (Hydrog. Off. 1951, Freeman 1951, Robson 1950, Chubb 1933) about 540 miles southwest of Panama. The island is 4 miles long by 2 miles wide. There are four peaks or hills, the highest of which rises to an altitude of 1,932 feet (Hydrog. Off., 1951; Chubb 1933, gives an altitude of 2,788 feet). From the main peak the ground slopes gradually to the summit of cliffs at a height of about 600 feet above sea level. The island is volcanic in origin and has a very irregular shore line obstructed by islets, rocks and shoal areas which may extend as much as one-half mile offshore. There are two principal bays or anchorages, Wafer and Chatham Bays, both of which are located on the northern side of the island. The water immediately surrounding the island is relatively shallow, ranging in depth from ¼ to 20 fathoms within 200 to 1,000 meters from the shore. The bottom at Chatham Bay, the area from which most of our Cocos Island specimens were taken, is of sand and large boulders. No coral reefs were observed. The surrounding water is clear, and the surface temperature at the time of our visit was 27° C. The extreme annual range is said to be about 5.5° C. A pounding surf about most of the island, except for some of the protected bays, makes boat landing a hazardous procedure.

The island has frequent torrential rains, luxuriant vegetation and an almost impenetrable jungle. Fresh-water streams and waterfalls are numerous. There is no human population at present. Wild goats were observed to be abundant. Hogs and rats are also reported to be present. Oceanic birds of various kinds are present in large numbers.

Collecting conditions at Chatham Bay were excellent for spear fishing, considerably better than any of the areas subsequently visited during the trip. White-tipped sharks, *Triaenodon obesus*, were found to be exceedingly abundant, but innocuous to skin divers. Various other species of shark were observed. Puffers, *Arothron setosus*, were present in large numbers. Fishes such as rainbow runners, jacks, triggerfish, filefish, surgeonfish, squirrelfish, blennies, butterflyfish, snappers, mackerels, half beaks, groupers, parrotfish, moray eels, trumpetfish, wahoo, skipjacks, yellowfin tunas, sailfish, were common.

MATERIALS AND METHODS

Collection of Fishes

The fish specimens were collected with the use of rotenone, spear, dynamite or dip net. Within a short time after collection the smaller specimens were sorted, labeled, placed in plastic bags according to the station from which they were taken, and frozen in a deep freeze unit. In the case of the larger specimens, samples were taken from the muscle, liver, intestines, and gonads in the field. An identification number was assigned to the tissue sample and a duplicate number given to the dissected fish which was then placed in a barrrel of 10 per cent formalin for future taxonomic purposes. The frozen material remained in that condition until tested in the laboratory. A considerable amount of ecological data was accumulated at each station and may be obtained from the authors. The stations from which the specimens used in this study were taken are K 52—10 to 15, 17 to 19, 21 to 22 (see Fig. 1).

Methods Used in Screening Fishes

Fishes were screened by preparing, whenever possible, aqueous extracts of muscle, liver, intestines, and gonads of each specimen. Four laboratory white mice were used for testing each extract. One ml. of the extract was used for each mouse. The mice were observed for a period of 36 hours and then classified as negative, weakly, moderately or strongly positive on the basis of symptoms developed. For details concerning the tech-

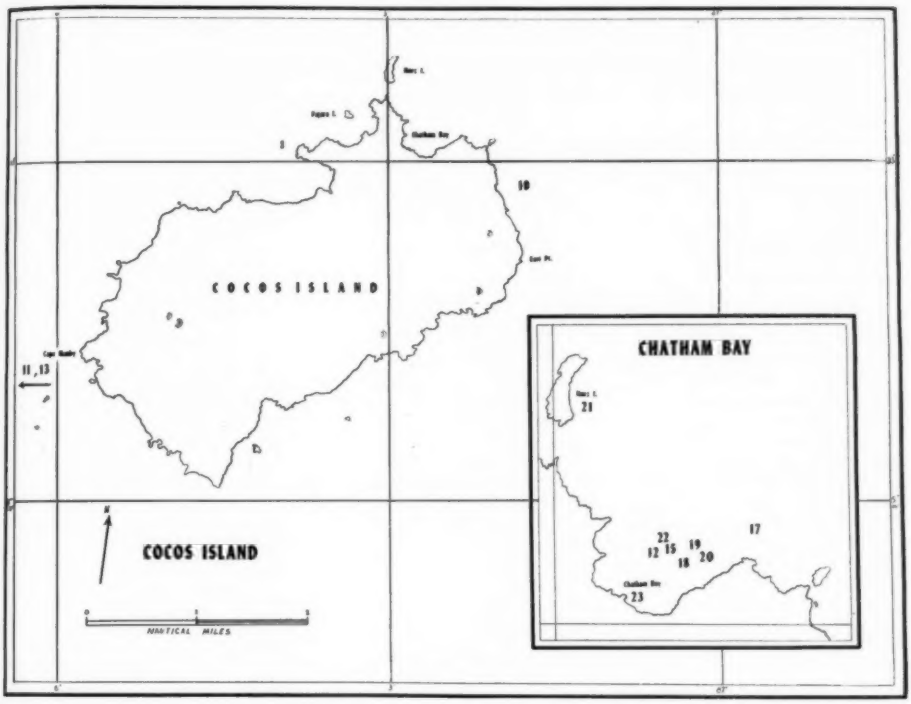

FIG. 1. Map of Cocos Island showing the locations (numbers 10–15, 17–19, 21, 22) at which specimens were collected.

niques used in testing for ichthyosarcotoxins see Halstead and Bunker (1954*a*).

Terminology Used Concerning Degrees of Toxicity

The classification used is an arbitrary one which gives some idea as to the degree of toxicity of a fish species within a particular geographical area. This method makes no attempt to differentiate between virulence and concentration. Moreover, the interpretation of *weakly positive* results in terms of human symptomatology is not clearly understood at this time. Hence, the reader is cautioned about arriving at hasty conclusions regarding the results of this study. The categories used are:

1. *Negative*—the test is negative if the mouse continues to remain asymptomatic during the maximum test period of 36 hours, or dies after that time.

2. *Weakly positive*—the test is weakly positive if the mouse shows definite symptoms such as lacrimation, diarrhea, ruffling of the hair, hypoactivity, ataxia, etc., but *recovers*.

3. *Moderately positive*—this term is used if the mouse develops hypoactivity, ruffling of the hair, lacrimation, diarrhea, paralysis, etc., and *dies within a period of 1 to 36 hours*.

4. *Strongly positive*—if the mouse develops hypoactivity, ataxia and paralysis which is usually followed by clonic or tonic convulsions of varying degrees, paradoxical respiration, respiratory paralysis, and *death occurs within a few seconds to one hour*.

TABLE 1

AN ANALYSIS OF COCOS ISLAND FISHES WITH REFERENCE TO THEIR TOXICITY
(Each specimen examined is listed separately)

FISH TESTED	EXTRACT TESTED*					
	Muscle	Liver	Gonads	Intestine	Viscera	Intestinal Content
ACANTHURIDAE—Surgeonfish						
Acanthurus aliala Lesson	–				–	
Acanthurus aliala Lesson	–			W		
Acanthurus crestonis (Jordan and Starks)	–	–	–	–		
Acanthurus crestonis (Jordan and Starks)	M				M	
Ctenochaetus strigosus (Bennett)	–				M	
ALUTERIDAE—Filefish						
Alutera monoceros Linnaeus	–	–		–		
Alutera monoceros Linnaeus	–	M	–	–		
Alutera monoceros Linnaeus	–	–		M		
Alutera monoceros Linnaeus	–	–		M		
BALISTIDAE—Triggerfish						
Balistes verres Gilbert and Starks	–				–	
Balistes verres Gilbert and Starks	–	–			–	
Balistes verres Gilbert and Starks	–				–	
Balistes verres Gilbert and Starks	W				–	
Balistes verres Gilbert and Starks	–	–		–		
Balistes verres Gilbert and Starks	–	–	–			
Balistes verres Gilbert and Starks	–	–		W		
Balistes verres Gilbert and Starks	–	–	–	–		
Melichthys radula (Solander)	–	–		–		
Melichthys radula (Solander)	–	–	–	–		
Melichthys radula (Solander)	–	–	–	–		
Melichthys radula (Solander)	–	W	–	M		
Melichthys radula (Solander)	–	–	–	–		
Melichthys radula (Solander)	–	–	–	–		
Melichthys radula (Solander)	–	W	–	–		
Melichthys radula (Solander)	–				–	
CARANGIDAE—Pompano, Jacks						
Caranx caballus Günther	M		W	M		
Caranx melampygus Cuvier and Valenciennes	–	–	–			
Caranx melampygus Cuvier and Valenciennes	–	–	–	W		
Caranx melampygus Cuvier and Valenciennes	W	–		–		
Elagatis bipinnulatus (Quoy and Gaimard)	–	–		–		
Elagatis bipinnulatus (Quoy and Gaimard)	–				–	
Elagatis bipinnulatus (Quoy and Gaimard)	–	–	–	–		
CONGRIDAE—Conger eels						
Chiloconger sp	–		–	W		
CYBIIDAE—Wahoo						
Acanthocybium solandri (Cuvier and Valenciennes)	–	–	–	–		
HAEMULIDAE—Grunts						
Anisotremus interruptus (Gill)	M	W	–	–		
Anisotremus interruptus (Gill)	–				–	
HOLOCENTRIDAE— Squirrelfish						
Holocentrus suborbitalis (Gill)	–				–	
Myripristis occidentalis Gill	–				–	
Myripristis occidentalis Gill	–	M	–			
Myripristis occidentalis Gill	–				–	
Myripristis occidentalis Gill	–				–	
Myripristis occidentalis Gill	–				–	
Myripristis occidentalis Gill	–				M	
Myripristis occidentalis Gill	–				–	

FISH TESTED	EXTRACT TESTED*					
	Muscle	Liver	Gonads	Intestine	Viscera	Intestinal Content
ISTIOPHORIDAE—Sailfish						
Istiophorus greyi Jordan and Hill	–	–	W	–		
KATSUWONIDAE—Skipjacks						
Euthynnus lineatus Kishinouye	–	–	W	–		
KYPHOSIDAE—Rudderfish						
Kyphosus sp.	–				–	
LUTJANIDAE—Snappers						
Aphareus furcatus (Lacépède)	–				–	
Aphareus furcatus (Lacépède)	–				–	
Aphareus furcatus (Lacépède)	–				M	
Aphareus furcatus (Lacépède)	–	W	–	–		
Aphareus furcatus (Lacépède)	–	–	–	M		
Aphareus furcatus (Lacépède)	–		–	–		
Lutjanus aratus (Günther)	W	M	–	–		
Lutjanus jordani (Gilbert)	–		–		–	
Lutjanus jordani (Gilbert)	–	–	–			
Lutjanus jordani (Gilbert)	–	–	–			
Lutjanus jordani (Gilbert)	–		–			
Lutjanus viridis (Valenciennes)	M				W	
Lutjanus viridis (Valenciennes)	–				–	
Lutjanus viridis (Valenciennes)	–				–	
Lutjanus viridis (Valenciennes)	–		–		–	
MULLIDAE—Surmullets						
Pseudupeneus xanthogrammus Gilbert	–	–		–		
Pseudupeneus xanthogrammus Gilbert	–				–	
Pseudupeneus xanthogrammus Gilbert	–		–	–		
POMACENTRIDAE—Damselfish						
Microspathodon bairdi (Gill)	–					
PRIACANTHIDAE—Big Eyes						
Priacanthus cruentatus (Lacépède)	–				–	
Priacanthus cruentatus (Lacépède)	–				–	
Priacanthus cruentatus (Lacépède)	–				M	
SCARIDAE—Parrotfish						
Scarid sp. nov.	–	M		–		
SERRANIDAE—Seabass						
Dermatolepis punctatus Gill	–	–	–	–		
Dermatolepis punctatus Gill	–	–	–	–		
Dermatolepis punctatus Gill	–		–	M		
Epinephelus labriformis (Jenyns)	–		–	–		
Epinephelus labriformis (Jenyns)	–		–	–		
Mycteroperca olfax (Jenyns)	–			–		
Mycteroperca olfax (Jenyns)	–	–	–	–		
Paranthias colonus (Valenciennes)	–				–	
Paranthias colonus (Valenciennes)	–				–	
Paranthias colonus (Valenciennes)	–				–	
SPARIDAE—Porgies, pargo						
Calamus taurinus (Jenyns)	–	W			M	
TETRAODONTIDAE—Puffers, Globefish						
Arothron setosus (Smith)	S				S	
Arothron setosus (Smith)	S	M		S		
Arothron setosus (Smith)	S				S	

TABLE 1 (*Continued*)

FISH TESTED	EXTRACT TESTED*					
	Muscle	Liver	Gonads	Intestine	Viscera	Intestinal Content
TETRAODONTIDAE—Puffers						
Arothron setosus (Smith)	S				S	
Arothron setosus (Smith)	S				S	
Arothron setosus (Smith)	S	S	S	S		
Arothron setosus (Smith)	S				S	
Arothron setosus (Smith)	S				S	
Arothron setosus (Smith)	S	S	S	S		
Arothron setosus (Smith)	—	S	—	—		M
Arothron setosus (Smith)	S				S	
THUNNIDAE—Tunas						
Neothunnus macropterus Temminck and Schlegel	—	—	—	—		
Neothunnus macropterus Temminck and Schlegel	—	M	—	—		
TRIAKIDAE—White-tipped sharks						
Triaenodon obesus (Rüppell)	—	—		—		
Triaenodon obesus (Rüppell)	—	—	—	—		

* Explanation of symbols used:
—, results negative; W, weakly toxic; M, moderately toxic; S, strongly toxic.

SUMMARY

Twenty-one families of Cocos Island fishes, representing 33 species and a total of 96 specimens were tested in this study. Of these, 22 species and 41 specimens, or about 67 per cent of the species and 43 per cent of the specimens, were found to be toxic. The musculature and viscera were tested on 95 cases. Seventeen specimens or 41 per cent of the toxic fishes had poisonous musculature, whereas 39 or about 95 per cent had toxic viscera. Both musculature and viscera were poisonous in 15, or 37 per cent, of the toxic specimens.

The fishes most likely to be used as food which were found to have toxic musculature included only five species:

Caranx caballus
Caranx melampygus
Anisotremus interruptus
Lutjanus aratus
Lutjanus viridis

It should be noted that two of the genera, *Caranx* and *Lutjanus*, are well established causative agents of ichthyosarcotoxism that have been incriminated in both the Caribbean Sea and throughout the tropical Pacific Ocean.

In general, the viscera are the portions of the fish which are most likely to be poisonous. A more complete analysis of the distribution of ichthyosarcotoxin in the body of the fishes examined is presented in Table 2. The fishes reported upon in this paper represent the major shore and some of the pelagic fish species likely to be used as food in the regions discussed. It was found that 76 per cent of the Cocos Island families contained toxic species.

The limited number of specimens collected for most of the species precludes the presentation of statistically valid results at this time. Much more study is necessary before definite conclusions can be reached regarding the edibility of species listed as "weakly positive" because of the difficulty of interpreting this reaction in terms of human symptomatology.

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TABLE 2
SUMMARY OF RESULTS OF TESTS FOR TOXICITY OF FISHES TAKEN AT COCOS ISLAND

	SPECIES	SPECIMENS	MUSCLE	LIVER	GONADS	INTESTINES	VISCERA	INTESTINAL CONTENT
Total Tested	33	96	96	46	42	48	41	1
Total Found Toxic	22	41	17	14	5	13	15	1
Percentage Found Toxic	67	43	18	30	12	27	37	100

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